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AGDISP COMPARISONS WITH FOUR FIELD DEPOSITION STUDIES

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Foreword

This Program WIND report is published as a part of the USDA Forest Service program to improve aerial application of pesticides, specifically by using pesticides and delivery systems tailored to the forest environment. The program is conducted jointly by the Technology and Development Center, Missoula, MT, and the Forest Pest Management Staff, Washington Office at Davis, CA, under the sponsorship of State and Private Forestry.

Details of the aerial application improvement program are explained in two Forest Service reports: A Problem Analysis: Forest and Range Aerial Pesticide Application Technology (Equipment Development Center Rpt. 7934 2804, July 1979, Missoula, MT) and Recommended Development Plan for An Aerial Spray Planning and Analysis System (Forest Pest Management Rpt. FPM 82-2, February 1982, Davis, CA).

The study was conducted as part of Program WIND (winds in nonuniform domains). Authority for the cooperative program is the Supplemental Agreement, dated February 1985, to the master Memorandum of Understanding Between U.S. Department of Defense and U.S. Department of Agriculture Relative to Cooperation with Respect to Food, Agriculture, and Other Research of Mutual Interest.

FPM 89-5

AGDISP Comparisons With Four Field Deposition Studies

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EXECUTIVE SUMMARY

Four deposition studies conducted by the U.S. Department of Agriculture Forest Service and the U.S. Army generate a significant data base with which to compare ground deposition predictions from the computer program AGDISP.

AGDISP predicts the motion of aerially released material, including the mean position of the material and the position variance about the mean as a result of turbulent fluctuations. AGDISP is based on a Lagrangian formulation of the released material equations of motion, and includes simplified models for aircraft wake and ambient turbulence effects. To this point AGDISP predictions have been compared with data in only one instance, by NASA Langley, and that comparison, while satisfactory, was restricted to material released from a fixed-wing aircraft.

In this report the four data sets examined include:

1. Program WIND Phase I test results from the Chico almond orchard tests conducted in 1985 with an AgCat biplane and Hiller 12E helicopter;

2. DC-7B aircraft spray tests conducted by the U.S. Army at Dugway Proving Grounds in 1974;

3. Program WIND Phase III test results from the Red Bluff forest tests conducted in 1986 with a C-130 and Bell Ranger 206 helicopter; and

4. Forest Service test results from the Withlacoochee seed orchard tests in 1980 with a Stearman biplane and Hughes 500C helicopter.

All test runs for which sufficient information is available to initialize the AGDISP code and make predictions of ground deposition are included in this report. The predictions compare favorably against the data.

Field tests, by their very nature, do not lend themselves to precise data collection. All of the parameters that could affect the material motion - aircraft weight, flight speed, altitude, material size and atmospheric wind conditions - usually carry some imprecision. Validation with AGDISP involves comparing the ground deposition pattern data with

AGDISP predictions. The current assessment of acceptability of the accuracy of the model is qualitative.

Results indicate the following:

1. For the most part the field tests were not conducted with the anticipation of AGDISP prediction. Thus, several assumptions and approximations had to be made to complete the necessary initial conditions, and to interpret the ground deposition data. Future field tests should be aware of the inputs needed by the AGDISP code, in an effort to remove ambiguity from the AGDISP predictions.

2. Over half of the field tests yielded ground deposition data below a canopy. Success in comparing predictions with these ground deposition data infers validation of the canopy deposition model. Without canopy deposition, AGDISP would overpredict ground deposition data.

3. All predictions were made assuming the volume median diameter (VMD) rather than a drop distribution (not available in all cases). These results suggest that smaller sized droplets should be included to capture the material drift that occurs downwind in several tests.

4. Several field test runs were compared with corrected data because the presence of moisture on the ground deposition cards results in abnormally high deposition readings from the image analyzer. A technique needs to be developed to calibrate the image analyzer when dealing with ground collection cards in moist atmospheric conditions. Such a procedure is suggested in the conclusions of this report.

1. INTRODUCTION

For the last fifteen years, the Forest Service of the United States Department of Agriculture and the United States Army have been pursuing the development of computer codes to predict the deposition distribution of aerially applied material. The two current codes under review are AGDISP (Teske, Ref. 1) and FSCBG (Curbishley and Skyler, Ref. 2).

AGDISP is based on a Lagrangian formulation of the released material equations of motion, and includes simplified models for aircraft wake and ambient turbulence effects. FSCBG considers multiple aircraft passes as Gaussian line sources of released material. The FSCBG model has had extensive comparisons with data (as referenced below) and subsequent model refinements, and includes a detailed canopy deposition model. AGDISP, on the other hand, has been compared with data in only one instance (Morris, et al., Ref. 3), and that comparison, while satisfactory, was restricted to material released from a fixed wing aircraft. Experimental field test data, collected for FSCBG comparison (Boyle, et al., Ref. 4, Barry, et al., Ref. 5 and Rafferty, et al., Ref. 6), and recent data collected from Program WIND (Keetch, Ref. 7 and Keetch, Ref. 8), provide additional sources of data with which to compare fixed and rotary wing predictions generated by AGDISP.

These four field experiments (Chico, Dugway, Red Bluff and Withlacoochee) form a significant data base with which to compare AGDISP predictions. This task is the subject of this report.

Section 2 of this report briefly summarizes the four test sets, and discusses any restrictions that may apply to them. Section 3 then contains the four data set comparisons of predicted and measured ground deposition. Section 4 offers conclusions.

2. SUMMARY OF TEST CONDITIONS

The four experimental data sets consist of the following, in alphabetical order:

1. Chico almond orchard tests (Ref. 7);
2. Dugway DC-7B aircraft tests (Ref. 4);
3. Red Bluff forest tests (Ref. 8); and
4. Withlacoochee seed orchard tests (Refs. 5 and 6).

Each of these four sets is summarized in subsequent subsections. Test information was obtained from the above referenced reports and from private communications. Aircraft characteristics were verified using Hardy (Ref. 9). Test conditions are summarized in Table 2-1.

2.1 Chico

The Chico tests were conducted between June 24 and July 4, 1985, in an instrumented section of an almond orchard outside Chico, California. The tests consisted of six passes each over card rows and towers as shown schematically in Figure 2-1. The aircraft passes were all north to south, and for our purposes, data will be compared on the coordinate system as shown, with positive y pointing west. Ground card data were collected on a downwind row, either row X or row Z as shown in the figure, and along rows B and D, plus at the base of the eight towers, numbered 1 through 8. The position of $y = 0$ is arbitrary, and used here only to align the AGDISP predictions with the collected data. A meteorological tower in an adjacent wheat field provided the wind speed and direction. The canopy profile was determined from Newton, et al. (Ref. 10).

The aircraft consisted of an AgCat biplane and a Hiller 12E helicopter. These aircraft flew at an altitude of 12.2 meters (Williamson, et al., Ref. 11) over selected tree rows, depending on the ambient winds at test time. The AgCat spray system consisted of six Micronair AU5000's, three on each wing, spraying at a rate of 20.5 gal/min. The volume median diameter of the released material was measured to be 189 microns (Yates and Cowden, Ref. 12).

The Hiller 12E spray system consisted of 28 nozzles uniformly spaced to three-quarters of the rotor radius. The nozzle type was D2-45, with a volume median diameter of released material of 251 microns (Ref. 12), at a flow rate of 5.4 gal/min.

Tests consisted of five runs (numbered A-1 to A-5) for the AgCat, and six runs (numbered B-1 to B-5 and C-1) for the Hiller 12E. Run C-1 positioned the helicopter just above the canopy, and drenched the ground deposition cards. For this reason data on run C-1 are unreliable, and predictions for it are not presented here.

2.2 Dugway

The Dugway tests were conducted between October 10 and 17, 1974, at Dugway Proving Grounds, Utah. These tests consisted of spray release from a DC-7B aircraft of small-sized material (50 to 68 microns volume median diameter) at either 25 or 60 gal/min, measuring drift effects over two extended grid systems (Figures 2-2 and 2-3) employing three rows of cards. There was no canopy. The area over which these tests were conducted was considerably larger than the other three data sets presented here. The small material size tests the limit of the AGDISP code to predict drift accurately. It is anticipated, in fact, that the height of the aircraft (from 27 to 52 meters) and subsequent entrainment of the material in the wing-tip vortices, will prevent all of the released material from reaching the surface.

In all, twelve tests were conducted, but for various reasons, only five (runs 1-5, 1-6 and 1-7 on the grid shown in Figure 2-2, runs 2-2R and 2-3 on the grid shown in Figure 2-3) were analyzed with the FSCBG code in the original research. We will restrict our predictions to these same five runs, since nearly complete input data is available for them in Ref. 4. The two coordinate systems chosen were positioned over the flight path of the DC-7B as it flew over the card rows. A meteorological tower provided the ambient wind speed and direction.

According to Ref. 4, 150 nozzles along a "full-span boom" were available on the DC-7B. With a material size of under 100 microns, the full simulation of any of the five Dugway test runs would be a formidable computational task. For this reason the aircraft dispersal system was modeled by positioning twenty nozzles uniformly along the wing span.

The results of this approximation, given in Section 3, show that less than 100 percent of the released material is predicted to deposit on the ground. This result is in contrast to the Chico, Red Bluff and Withlacoochee data sets, where 100 percent is deposited in all cases (on the ground or in the canopy).

2.3 Red Bluff

The Red Bluff tests were conducted from April 23 to May 7, 1986, in a forested site outside Red Bluff, California (Figure 2-4). The aircraft flew multiple passes north to south over long card rows spaced 50 meters or more apart. These card rows were positioned deep into the forest area, and out into the open field to the west. Predictions are compared on the coordinate system shown in Figure 2-4, where $y = 0$ is centered over the H row, and positive y points west. A meteorological tower off to the west in the open field provided the wind speed and direction used in the AGDISP predictions. The canopy profile was described in Rafferty, et al. (Ref. 13).

The aircraft consisted of a C-130 flying six runs (numbered A-1 to A-6), and a Bell Ranger 206 helicopter flying four runs (numbered B-1 to B-4). The C-130 flew at altitudes ranging between 46 and 76 meters, and was equipped with either 50 or 64 Tee Jet 8020 nozzles, whose volume median diameter of released material was measured to be 394 microns (Yates, et al., Ref. 14). Each of the C-130 runs consisted of six to ten passes.

The C-130 released spray at either 116 gal/min (for 50 nozzles) or 149 gal/min (for 64 nozzles). In all AGDISP C-130 simulations, only 50 nozzles were used, since Putnam (private communication) could accurately position these nozzles between 15.4 and 18.9 meters from the fuselage centerline along either wing. The recorded value of spray flow rate was used regardless of the number of nozzles considered.

The Bell Ranger 206 spray system consisted of 34 nozzles positioned nonuniformly along the spray boom (Barry, private communication). The nozzles were D4-45 with a volume median diameter of released material measured to be 264 microns (Ref. 12). The spray was released at 12.2 gal/min from an altitude of 46 meters.

In an open field near Red Bluff, additional characterization runs were made for both aircraft. A single card row (with uniformly spaced cards) was set, and the C-130 flew over the row once, at an altitude of 46 meters (Biery, Ref. 15). The Bell Ranger 206 made three

flights 15 meters above a similar card row, to collect three sets of data presented here as one set. Unfortunately, in the characterization studies, the ambient winds were not recorded. It was merely mentioned that the aircraft flew into the wind. Consequently, the precise wind conditions were not known, and we needed to estimate the ambient turbulence level in these cases for the AGDISP comparisons.

2.4 Withlacoochee

The Withlacoochee tests were conducted February 15 to 20, 1980, at a seed tree orchard in Florida. The sampling set-up is shown schematically in Figure 2-5. The coordinate system positions $y = 0$ over tree row 10, with positive y pointing east. This coordinate system is consistent with the coordinate system established in Refs. 5 and 6 to analyze the Withlacoochee data using FSCBG. The canopy profile was described in Ref. 6.

The aircraft consisted of a Stearman biplane and a Hughes 500C helicopter. Each of twelve runs consisted of multiple north to south and south to north passes, either over tree rows or between tree rows. The data available is the averaged data along tree rows.

The mean canopy height was 13 meters (Barry, private communication), and flights were at either 1.5 or 6 meters above the canopy. The target volume median diameter of the released material was 350 microns. For various reasons, only runs W-2, W-3, W-5, W-6 and W-7 were valid for the Stearman, and runs W-10, W-11 and W-13 for the Hughes 500C. In addition, a burned-out pump bearing severely restricted the spray in run W-7, and some approximation of its spray rate must be made. The anticipated application rate was 5 gal/acre on a 9.1-meter swath width, yielding an application rate for the Stearman of 27.3 gal/min, and for the Hughes 500C, 7.6 gal/min.

The Stearman spray system consisted of 27 D6-46 nozzles placed nonuniformly along the wing span. The Hughes 500C spray system employed both front and rear spray booms with 48 D2-45 nozzles (Barry, private communication) spaced nonuniformly.

Table 2-1

Summary of Field Deposition Studies

Location	Chico	Dugway	Red Bluff	Withlacoochee
Dates	06/24/85 07/04/85	10/10/74 10/17/74	04/23/86 05/07/86	02/15/80 02/20/80
Number of Runs	10	5	12	8
Number of Passes per Run	6	1	1 to 10	7 to 10
Altitude (m)	12.2	27 to 52	15.2 to 76.2	14.6 or 18.8
Aircraft #1	AgCat	DC-7B	C-130	Stearman
Nozzle Type	Micronair	-	Tee Jet 8020	D6-46
Number of Nozzles	6	150	50 or 64	27
Spray Rate (gal/min)	20.5	25 or 60	116 or 149	27.3
Volume Median Diameter (microns)	189	50 to 68	394	350
Aircraft #2	Hiller 12E		Bell Ranger 206	Hughes 500C
Nozzle Type	D2-45		D4-45	D2-45
Number of Nozzles	28		34	48
Spray Rate (gal/min)	5.4		12.2	7.6
Volume Median Diameter (microns)	251		264	350

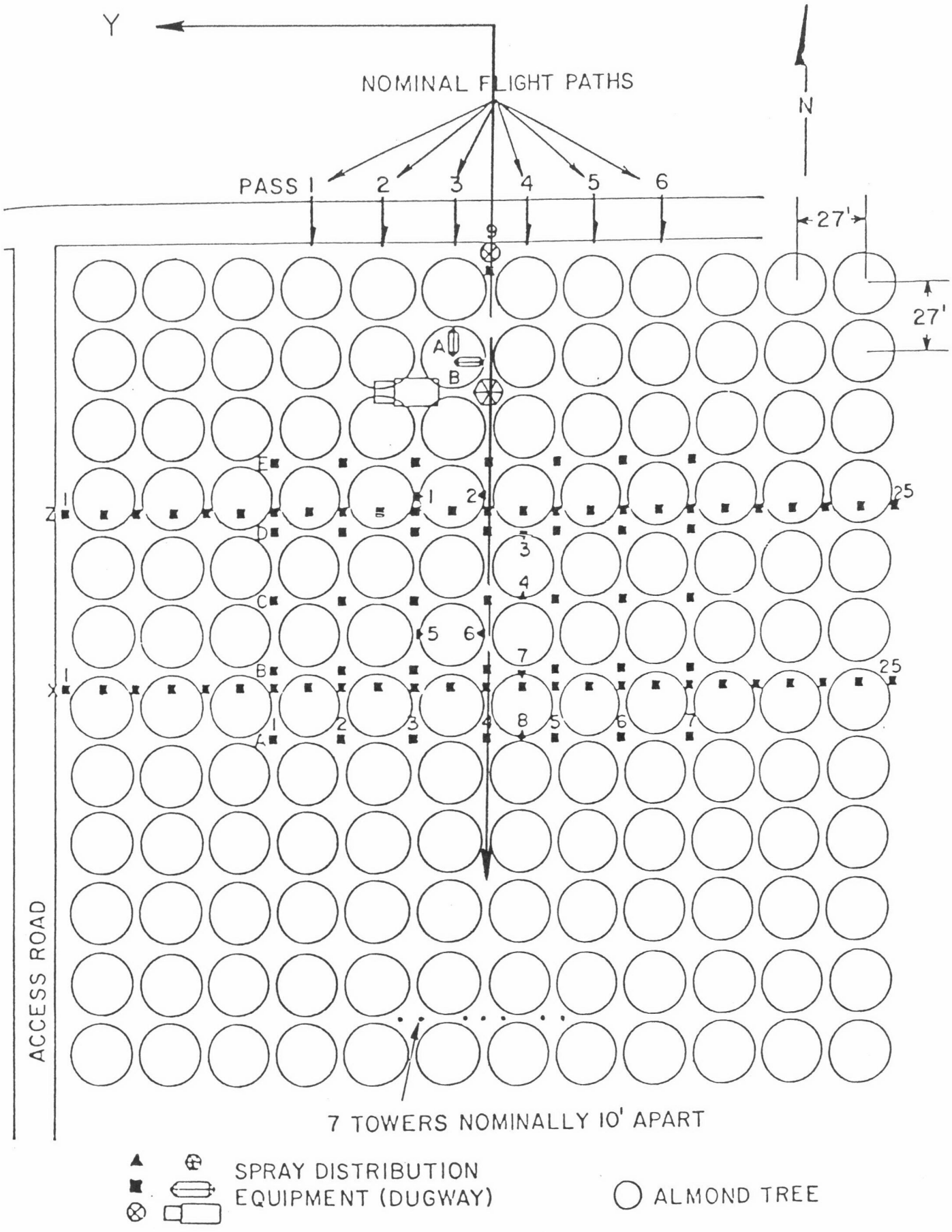

Figure 2-1. Schematic of Chico almond orchard test site.

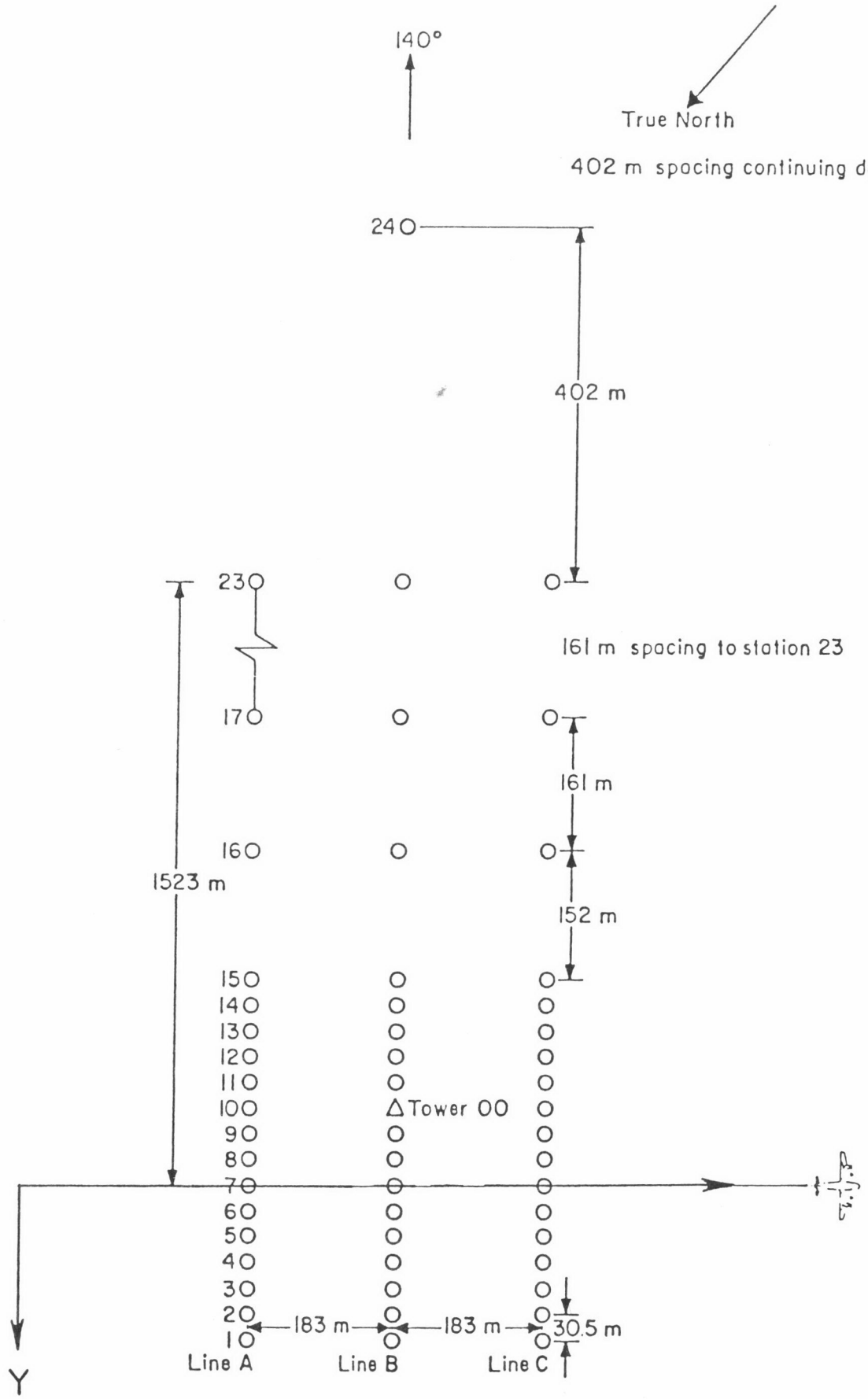

Figure 2-2. Schematic of Dugway test site for runs 1-5, 1-6 and 1-7.

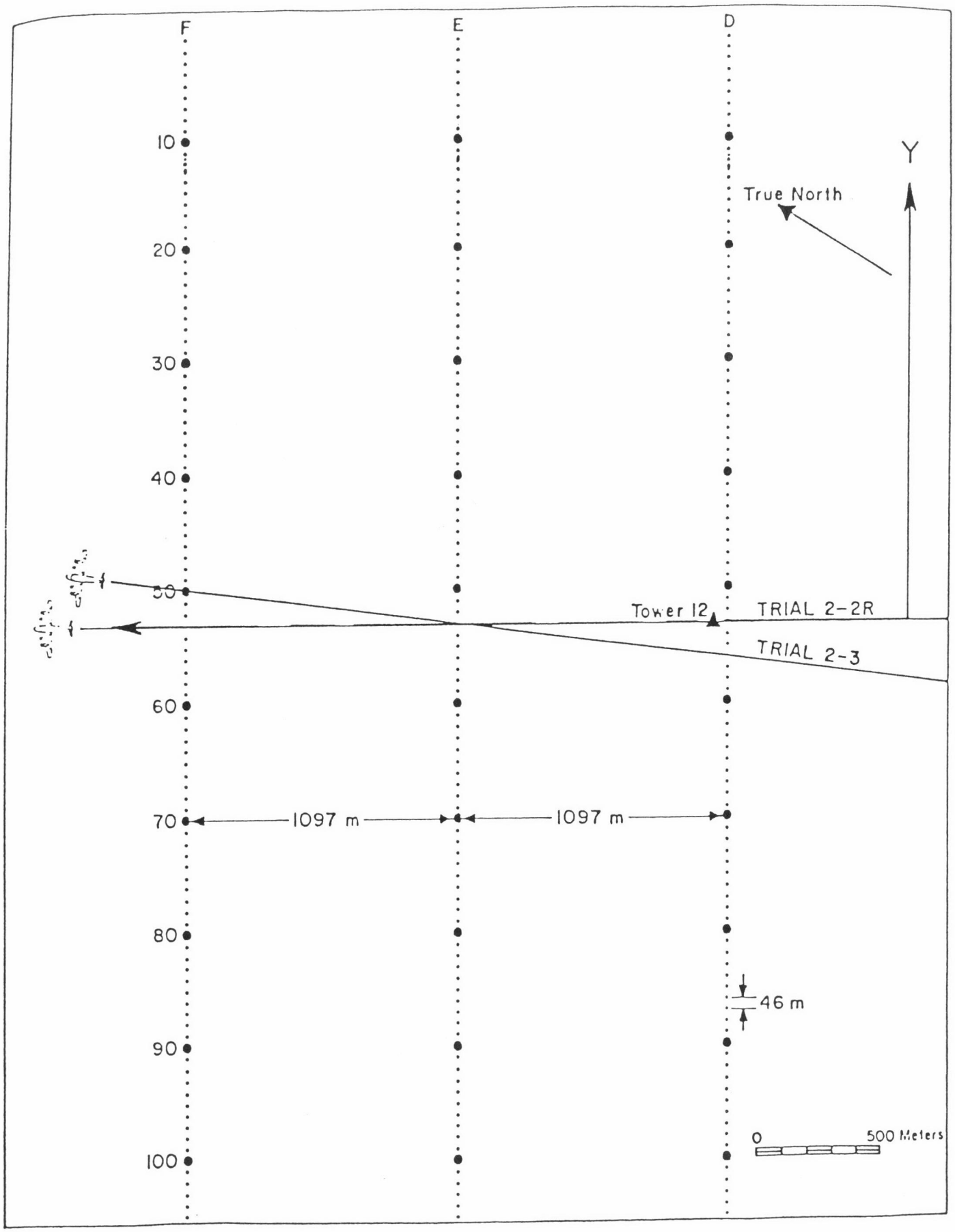

Figure 2-3. Schematic of Dugway test site for runs 2-2R and 2-3.

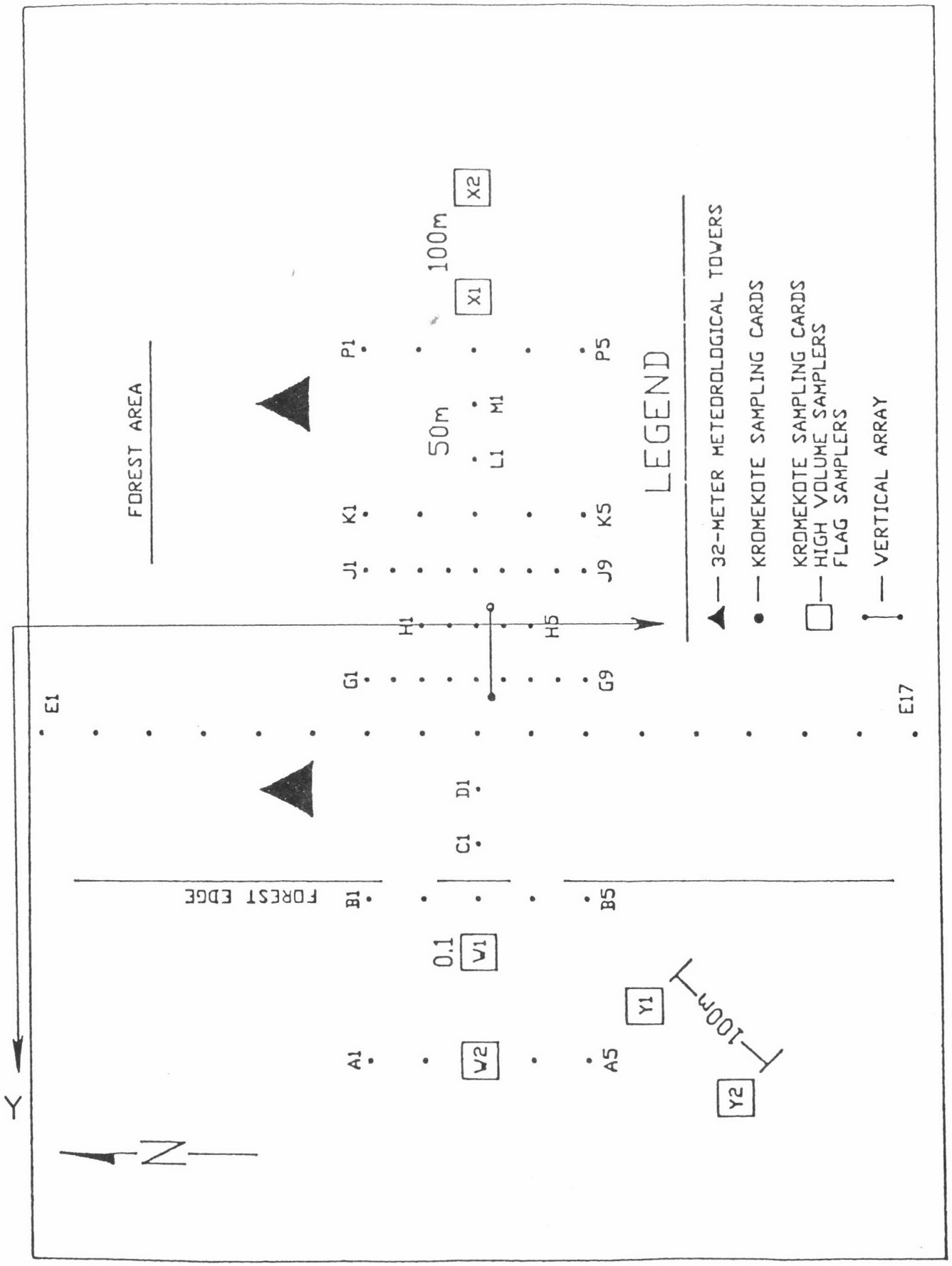

Figure 2-4. Schematic of Red Bluff forest test site.

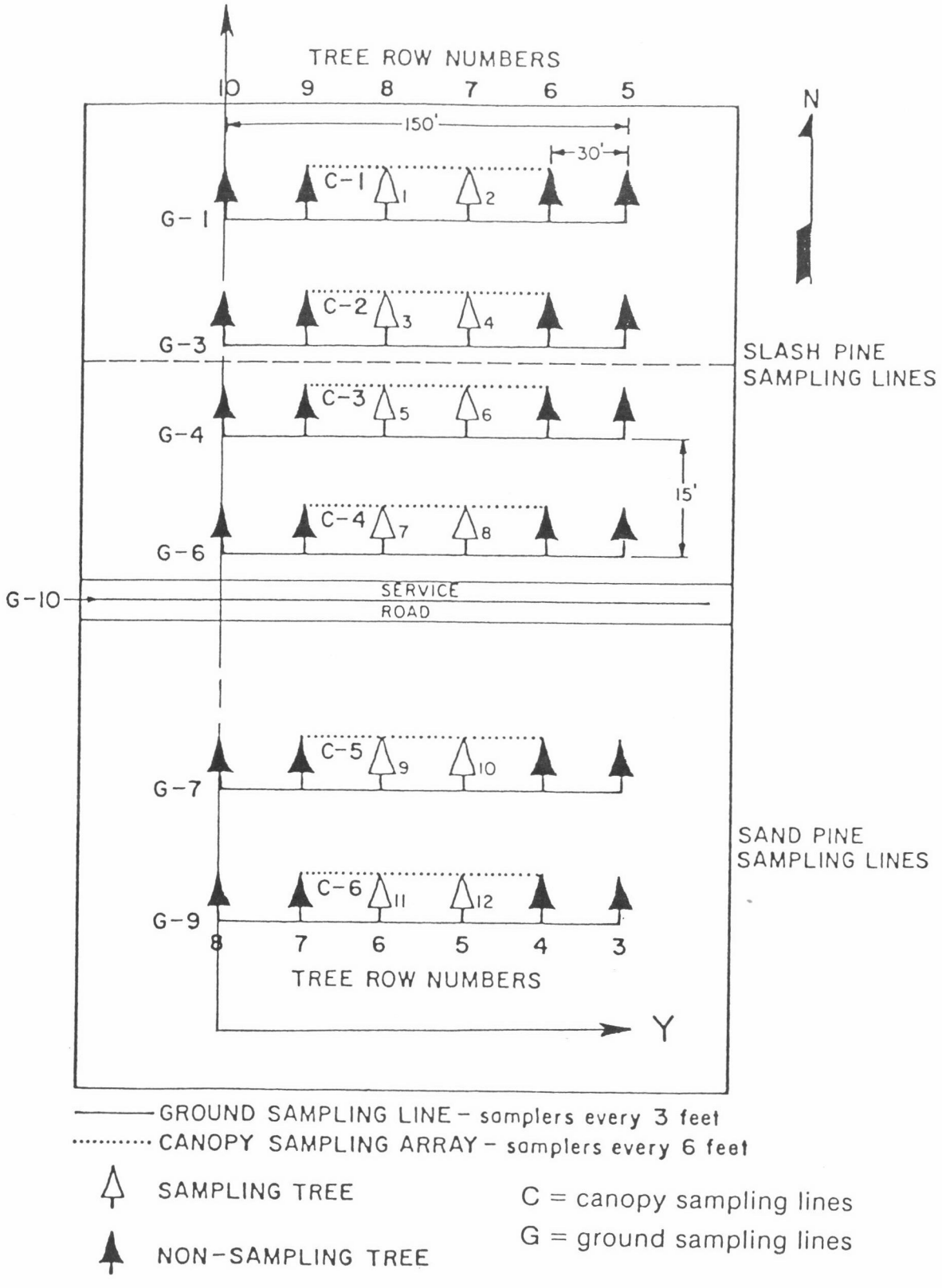

Figure 2-5. Schematic of Withlacoochee seed orchard test site.

3. AGDISP MODEL COMPARISONS

In this section we present comparisons between the ground deposition card data at Chico, Dugway, Red Bluff and Withlacoochee, and AGDISP predictions.

While the data was recorded as carefully as possible, several sources cited in Section 2 of this report conflict with information found from other sources. While aircraft spray passes were recorded with some accuracy, the anticipation is that these paths were only approximately correct, particularly at Red Bluff (Keetch, private communication). The aircraft weights were in some cases approximated, and the flight speeds were averaged, particularly at Chico. All of these data are required input to AGDISP; therefore, it became necessary to select the most reasonable values, relying on first-hand accounts of the tests. This is what was done.

It should be noted that the Dugway and Withlacoochee tests were run before the AGDISP code was developed. Therefore, it is not surprising that inputs needed for AGDISP would not necessarily have been recorded. The later tests at Chico and Red Bluff included additional test data needed to initialize the AGDISP predictions.

The nominal wind speed and direction are critical to the selection of the crosswind profile and the ambient background turbulence level. In all cases these values were available in the open field out of canopy effect. As the material entered the canopy, it would be subject to in-canopy winds that were not the same as the open field measurements. The reader will see numerous instances below where AGDISP predictions, based on open field velocity measurements, appear to be shifted from the measured deposition patterns. Although AGDISP contains a canopy model that modifies the velocity and turbulence levels within the canopy, it did not in all cases account for the diminished canopy wind.

AGDISP follows material trajectories from one aircraft spray pass until the material hits the ground. The continuous ground deposition model sums the deposition of the Gaussian tail of the material as the material approaches the ground. These results were then added together appropriately to represent multiple aircraft passes over the card rows. Clearly, six passes of an aircraft from south to north over different y positions requires only one AGDISP run and a small computer program to combine the AGDISP results six times. In Withlacoochee the Stearman biplane flew south to north and north to south,

requiring two AGDISP runs to account for the crosswind effect in the asymmetrical aircraft wake produced by the propeller.

All predictions shown below were made at only one material size: the volume median diameter of the released material.

Each subsection that follows compares the appropriate test data with AGDISP predictions.

3.1 Chico AgCat Tests A-1 to A-5

The Chico AgCat predictions are shown in Figures 3-1 to 3-5 for the five test runs A-1 to A-5, respectively. Each run consisted of six passes over selected tree rows in the almond orchard (see Figure 2-1 for a schematic).

The comparisons are favorable in all five runs. To achieve these results required an AGDISP canopy capture efficiency parameter of 1.6 (a value of 2.0 implies that both sides of all canopy surfaces are wetted). This large a value (a typical value is 0.2, used in all other canopy comparisons in this report) suggests that the canopy removes most of the released material before it reaches the surface, or that the canopy description in Ref. 10 is incorrectly applied here.

3.2 Chico Hiller 12E Tests B-1 to B-5

The Chico Hiller 12E predictions are shown in Figures 3-6 to 3-10 for the five tests B-1 to B-5, respectively. Each test again consists of six passes over selected tree rows in the almond orchard.

The comparisons are again quite favorable, although the crosswind effect is not matched with the data in all cases.

3.3 Dugway DC-7B Tests 1-5, 1-6, 1-7, 2-2R and 2-3

The Dugway DC-7B predictions are shown in Figures 3-11 to 3-15 for runs 1-5, 1-6, 1-7, 2-2R and 2-3 respectively. Each deposition was made by a single aircraft pass with the prediction assuming twenty nozzles across the wing span, and the deposition

efficiencies of Ref. 4 (to correct for evaporative effects). Qualitative agreement with the data is seen except in 1-5 (Figure 3-11) and 2-2R (Figure 3-14). There is no canopy in these tests.

The predicted deposition is 45% for 1-5, 78% for 1-6, 22% for 1-7, 50% for 2-2R and 19% for 2-3. The rest of the spray drifts downwind off the figure. The card data shown here suggest that deposition is 12% for 1-5, 60% for 1-6, 11% for 1-7, 15% for 2-2R and 7% for 2-3. AGDISP overpredicts in all cases.

3.4 Red Bluff C-130 Tests A-1 to A-6

The Red Bluff C-130 predictions are compared against data in Figures 3-16 to 3-21 for the six runs A-1 to A-6, respectively. Each run consisted of two passes of the C-130 aircraft.

The distinctive feature of these predictions are the spiked deposition patterns, one from each side of the aircraft for each of the two passes. The predictions do a good job of bounding the measured ground deposition data. Only in test A-5 (Figure 3-20) are the predictions noticeably lower than the data. The sparseness of the canopy enables a wide difference in measured deposition along card rows.

The drawback in making predictions with only one material size may be seen in tests A-2 (Figure 3-17), A-4 (Figure 3-19) and A-6 (Figure 3-21), where deposition has drifted into the open field. The open field begins at a distance of approximately 230 meters to the right of center. The deposition recorded in the open field is the result of smaller material sizes not predicted here.

3.5 Red Bluff Bell Ranger 206 Tests B-1 to B-4

The Red Bluff Bell Ranger 206 card data are compared with AGDISP predictions in Figures 3-22 to 3-25 for runs B-1 to B-4, respectively. These tests consisted of six passes for B-1, ten passes for B-2, nine passes for B-3 and ten passes for B-4.

The Bell Ranger 206 predictions for B-1 (Figure 3-22) and B-2 (Figure 3-23) cover much of the data but do not envelop the peak values. The original data for tests B-3 and B-4 show that both card sets experienced severe moisture problems. If we look at the middle

deposition rows (rows E, G, H, J and K in Figure 2-4) and compare the averaged card deposition value in B-2 with B-3 and B-4, we find that the data cards collected 8.3 times as much deposition per pass in B-3 as in B-2, and 10.6 times as much deposition per pass in B-4 as in B-2. To correct for this, the data in B-3 have been divided by 8.3, and the data in B-4 have been divided by 10.6. AGDISP predictions are in good agreement with these modified data sets as seen in Figures 3-24 and 3-25.

It is our understanding that moisture degrades the ability of the image analyzer to determine material deposition diameters. Material hitting the wet cards will have a tendency to spread more, creating the illusion of a larger material drop. Clearly, some provision should be made to account for moisture on the ground collection cards.

3.6 Red Bluff Characterization Tests

The two Red Bluff characterization tests (in an open field) are shown in Figure 3-26 for the C-130 test and in Figure 3-27 for the three Bell Ranger 206 tests. Both characterization runs lack wind measurements, and were conducted with the aircraft flying into the wind, although both figures show a right-to-left crosswind effect. The C-130 result for a single pass (Figure 3-26) was obtained by assuming that the ambient turbulence level was 20 m^2/sec^2, to account for the highly turbulent C-130 aircraft wake. In addition, an integral under the deposition data curve recovers a spray emission rate of 276 gal/min, well in excess of the 149 gal/min suggested by the documentation (Refs. 8 and 15). The data in C-1 have been divided by 1.9 to correct for this discrepancy. AGDISP predictions are in good agreement with the modified data set.

The Bell Ranger 206 characterization runs also suffer from a spray emission rate error. The data in Figure 3-26 are from the three Bell runs BC-1, BC-2 and BC-3 (Ref. 8). An integral of the ground deposition data gives approximately 94.3 gal/min, well in excess of the 12.2 gal/min expected. The data in C-2 have been divided by 7.7 to correct for this discrepancy. AGDISP predictions, assuming a nominal ambient turbulence level of 1 m^2/sec^2, are in good agreement with the modified data set.

3.7 Withlacoochee Stearman Tests W-2, W-3, W-5, W-6 and W-7

The Withlacoochee Stearman data comparisons are shown in Figures 3-28 to 3-32 for tests W-2, W-3, W-5, W-6 and W-7, respectively. In these tests there were seven

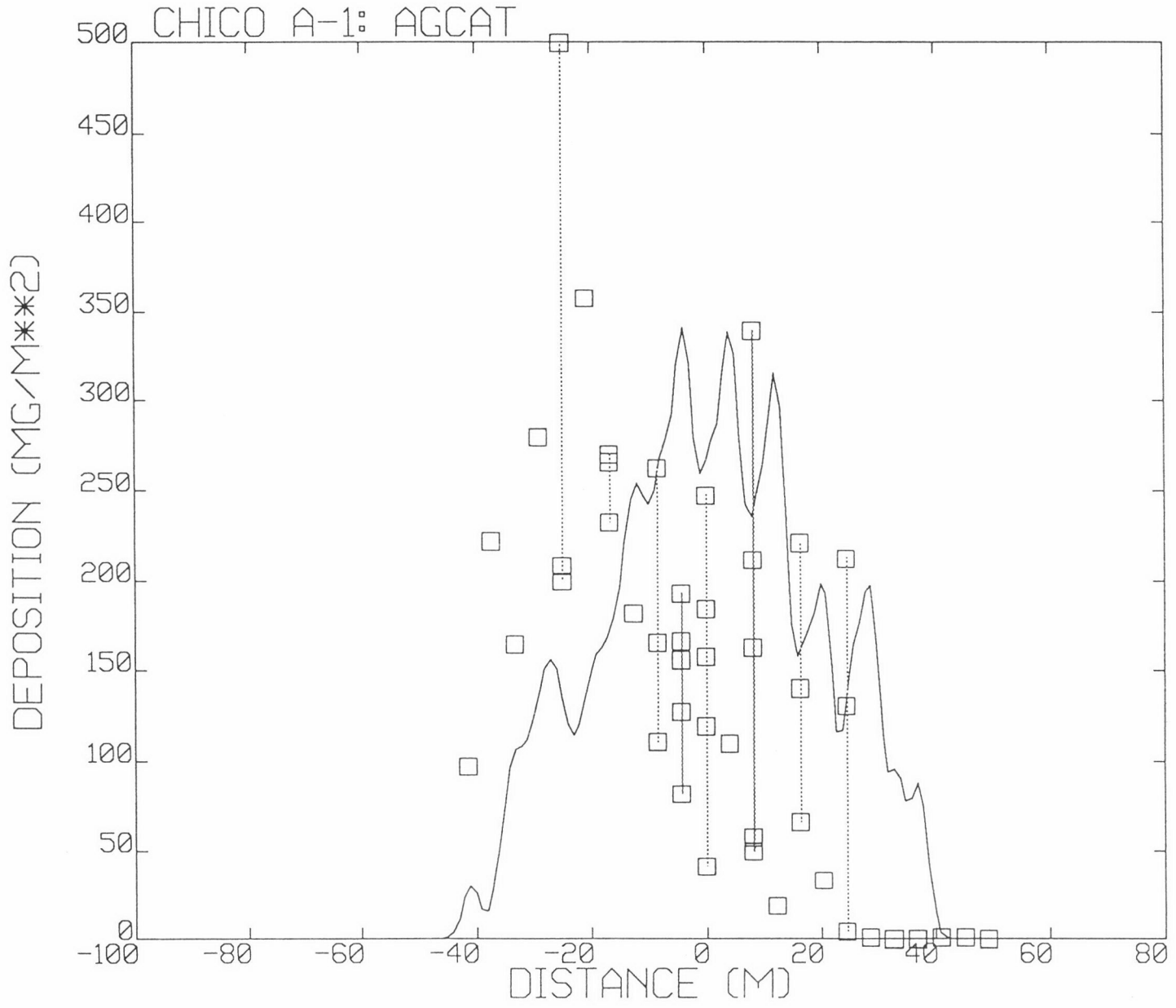

Figure 3-1. Predicted (solid curve) and measured (open squares) ground deposition pattern for run A-1 at Chico (AgCat). The dashed lines connect data points at the same lateral position.

passes for W-2, eight passes for W-3 and nine passes for W-5, W-6 and W-7. W-7 suffered from a burned-out pump bearing, and its actual spray flow rate has been adjusted as discussed previously. All of the data points shown in these (and subsequent) plots are the averaged data digitized from plots found in Ref. 6. The actual data along all available card rows would show scatter.

These five figures show that AGDISP bounds the averaged data with the exception of W-2. In all cases the predictions extend laterally beyond the data (data cards were not placed wide enough). The W-7 comparison is an estimate at best.

3.8 Withlacoochee Hughes 500C Tests W-10, W-11 and W-13

The Withlacoochee Hughes 500C predictions are shown in Figures 3-33 to 3-35 for tests W-10, W-11 and W-13, respectively. In these tests there were ten passes in W-10 and nine passes in W-11 and W-13. Again, the predictions do a good job of comparing with the averaged data.

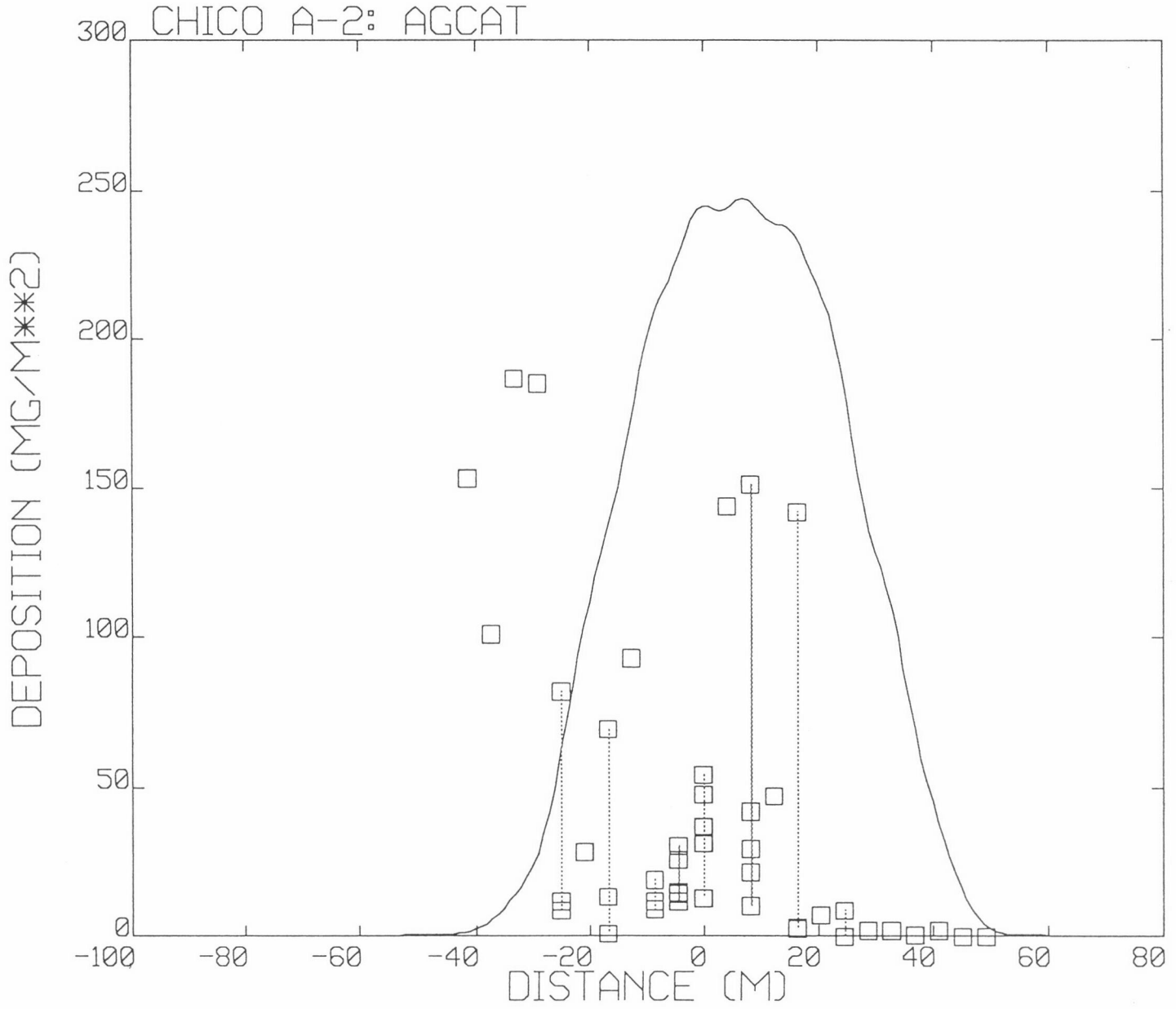

Figure 3-2. Predicted (solid curve) and measured (open squares) ground deposition pattern for run A-2 at Chico (AgCat).

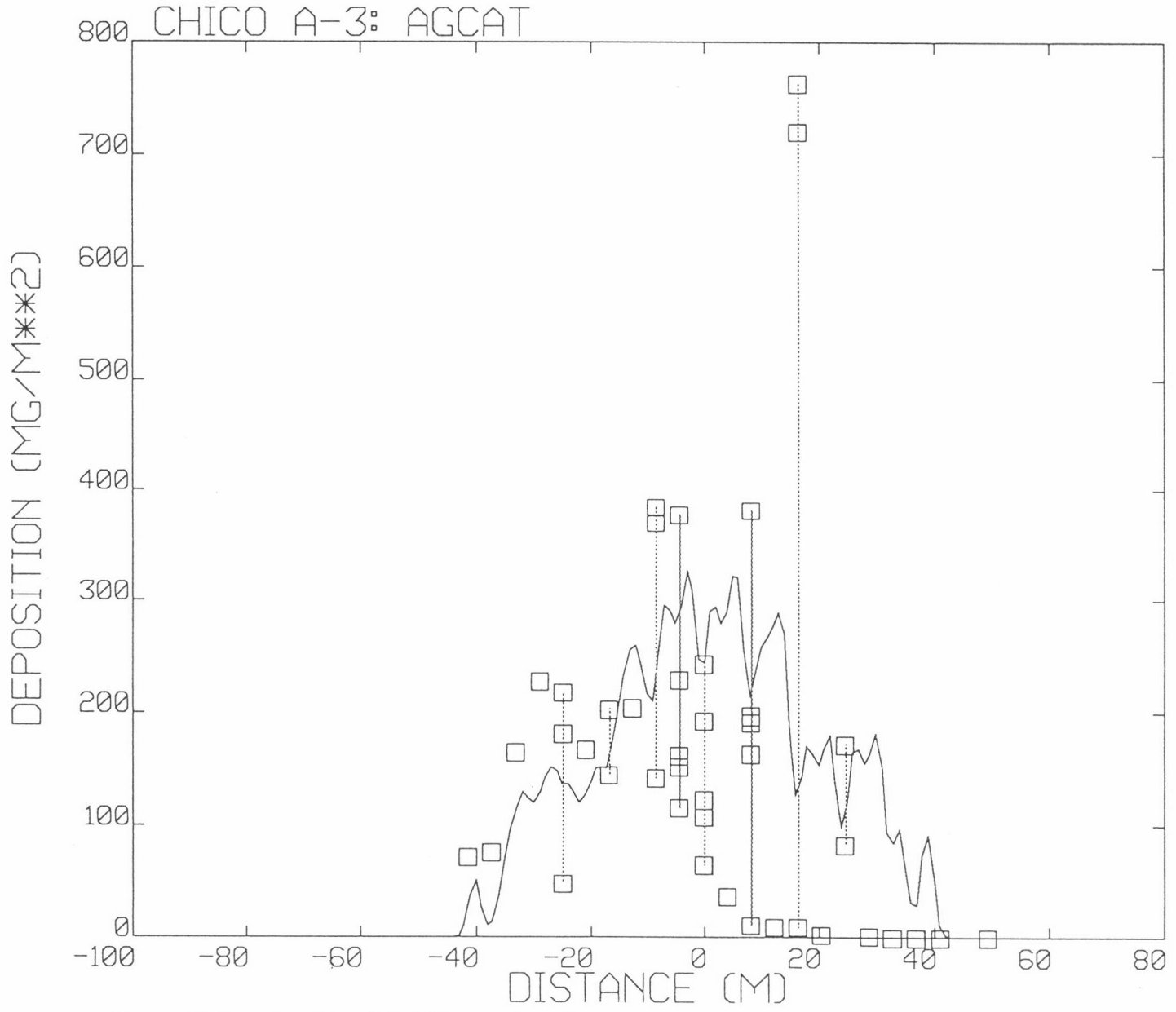

Figure 3-3. Predicted (solid curve) and measured (open squares) ground deposition pattern for run A-3 at Chico (AgCat).

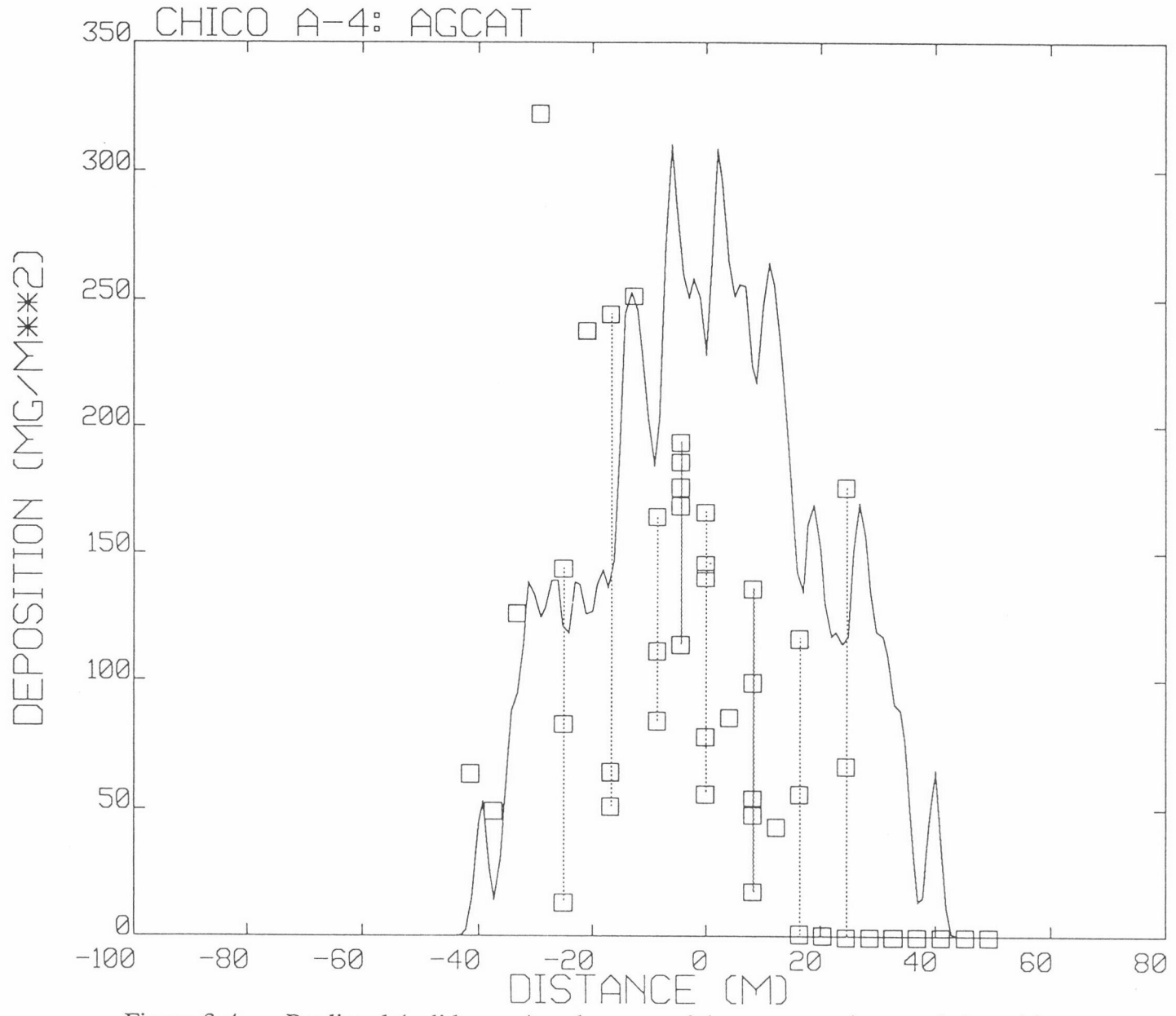

Figure 3-4. Predicted (solid curve) and measured (open squares) ground deposition pattern for run A-4 at Chico (AgCat).

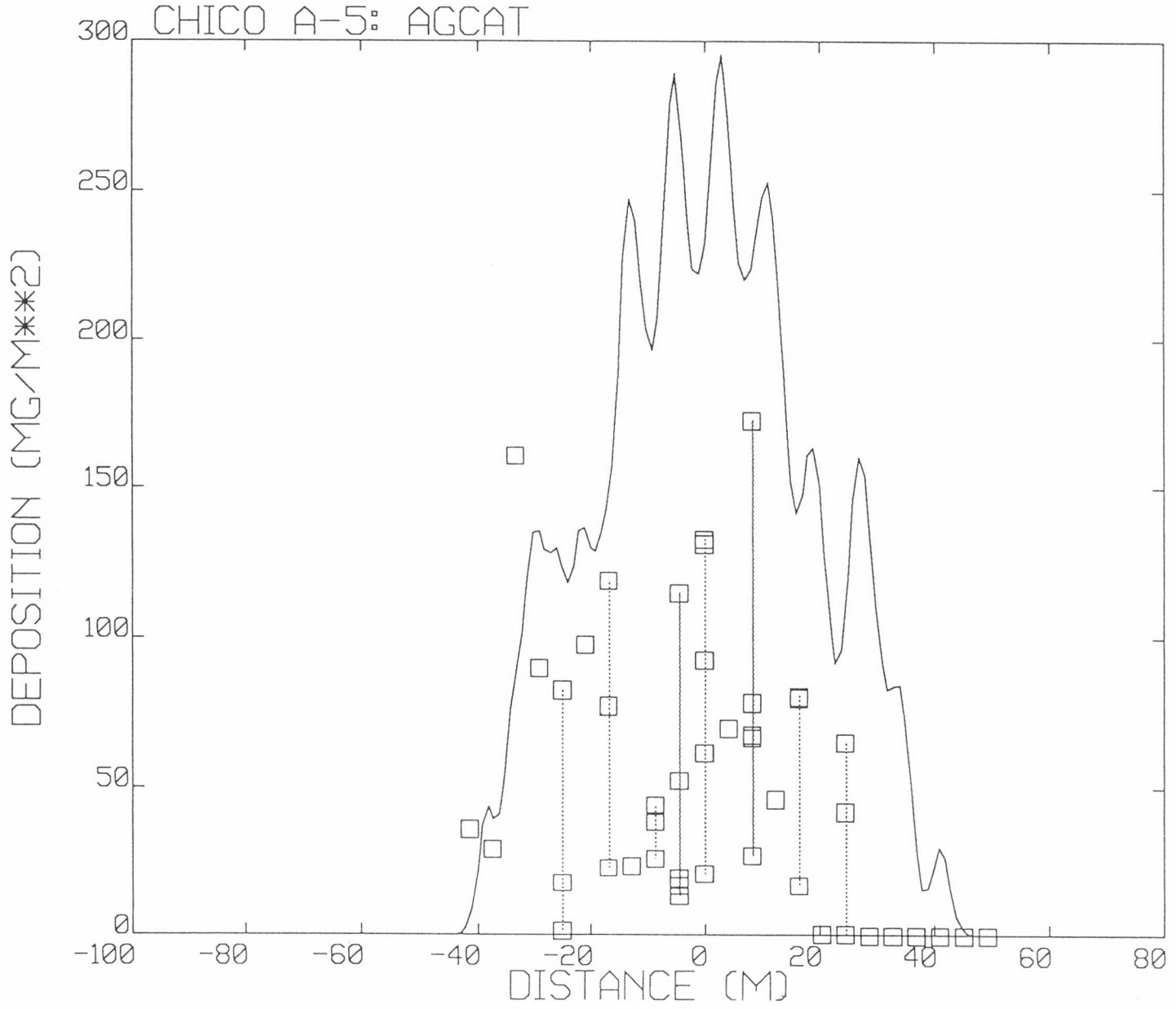

Figure 3-5. Predicted (solid curve) and measured (open squares) ground deposition pattern for run A-5 at Chico (AgCat).

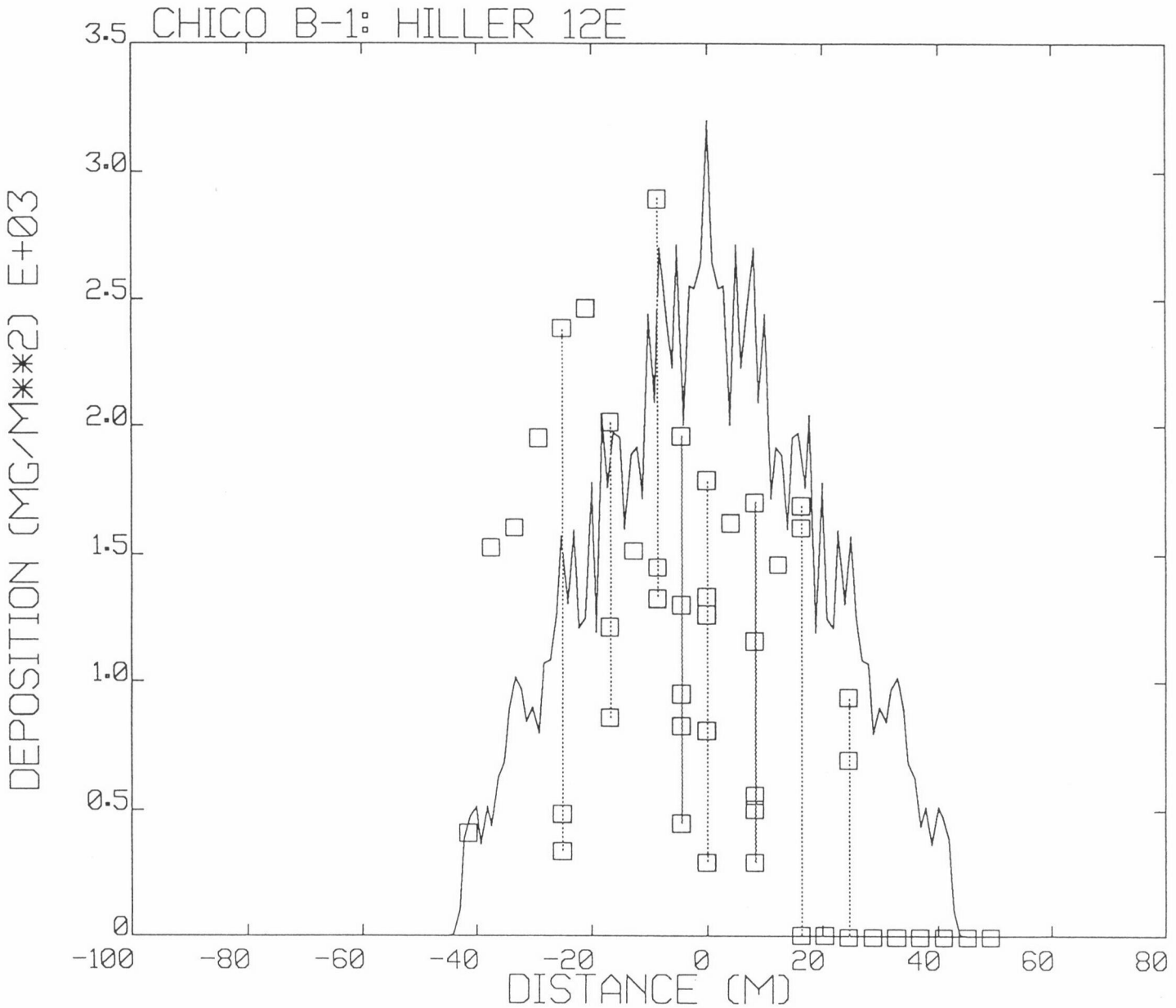

Figure 3-6. Predicted (solid curve) and measured (open squares) ground deposition pattern for run B-1 at Chico (Hiller 12E).

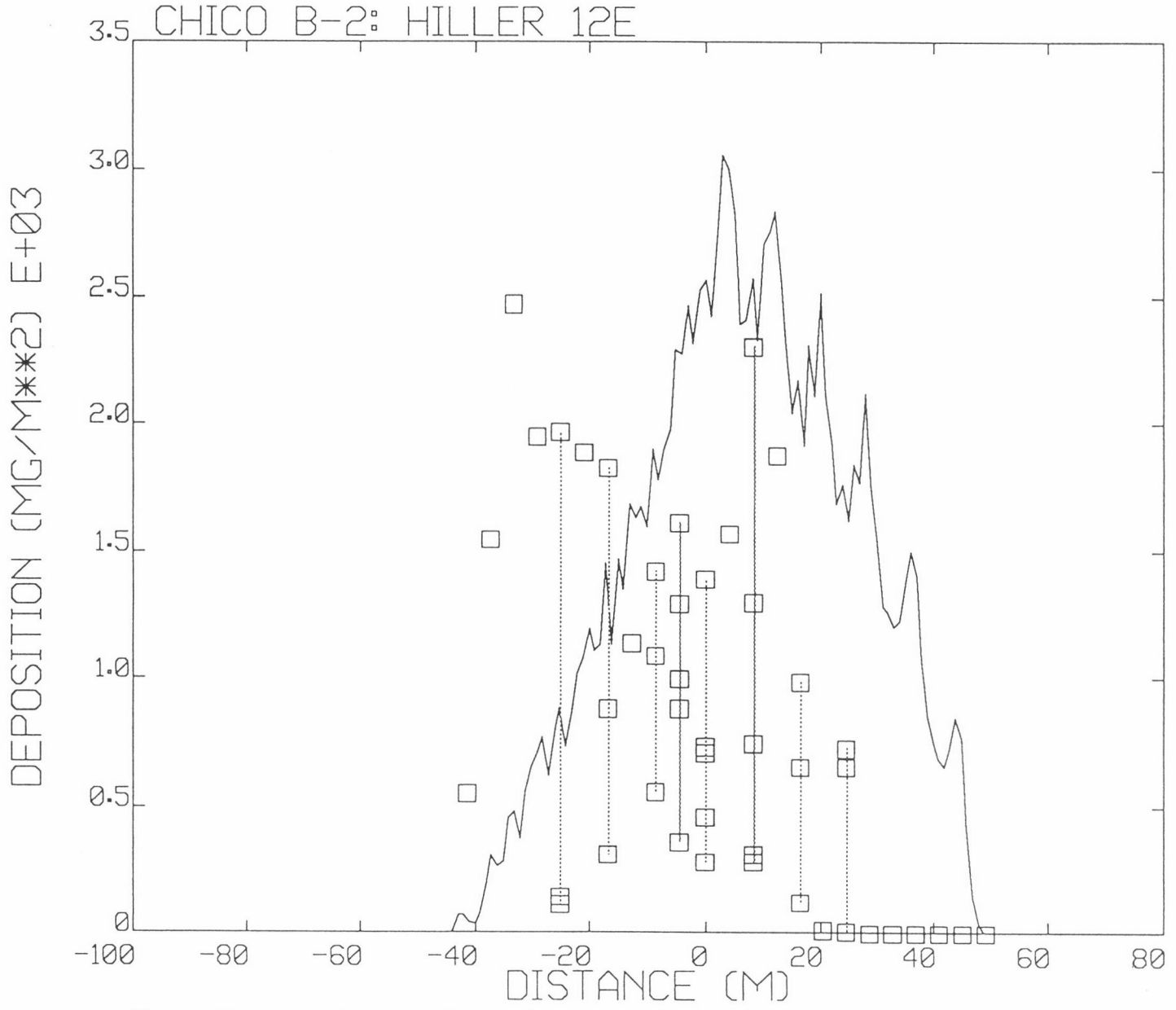

Figure 3-7. Predicted (solid curve) and measured (open squares) ground deposition pattern for run B-2 at Chico (Hiller 12E).

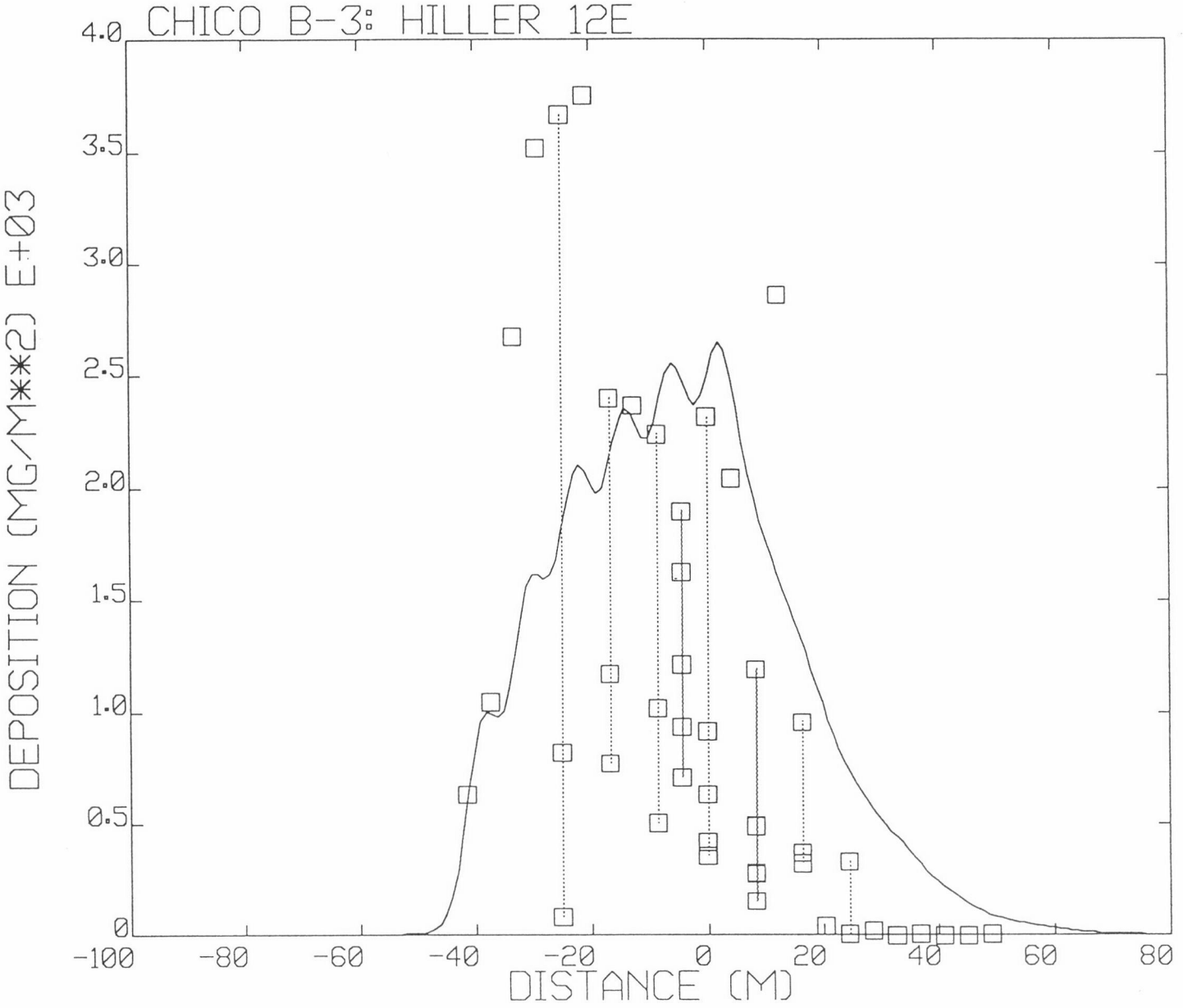

Figure 3-8. Predicted (solid curve) and measured (open squares) ground deposition pattern for run B-3 at Chico (Hiller 12E).

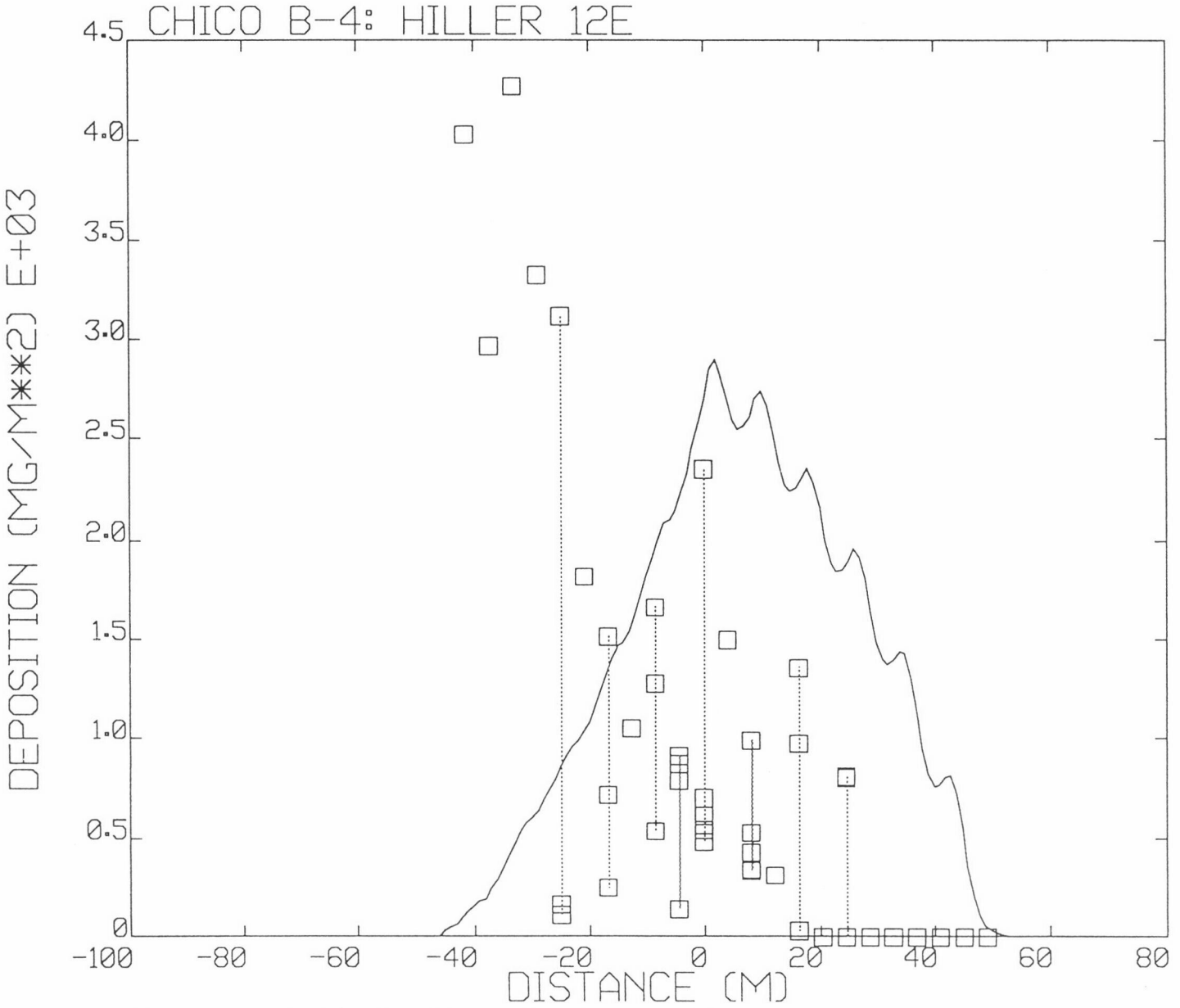

Figure 3-9. Predicted (solid curve) and measured (open squares) ground deposition pattern for run B-4 at Chico (Hiller 12E).

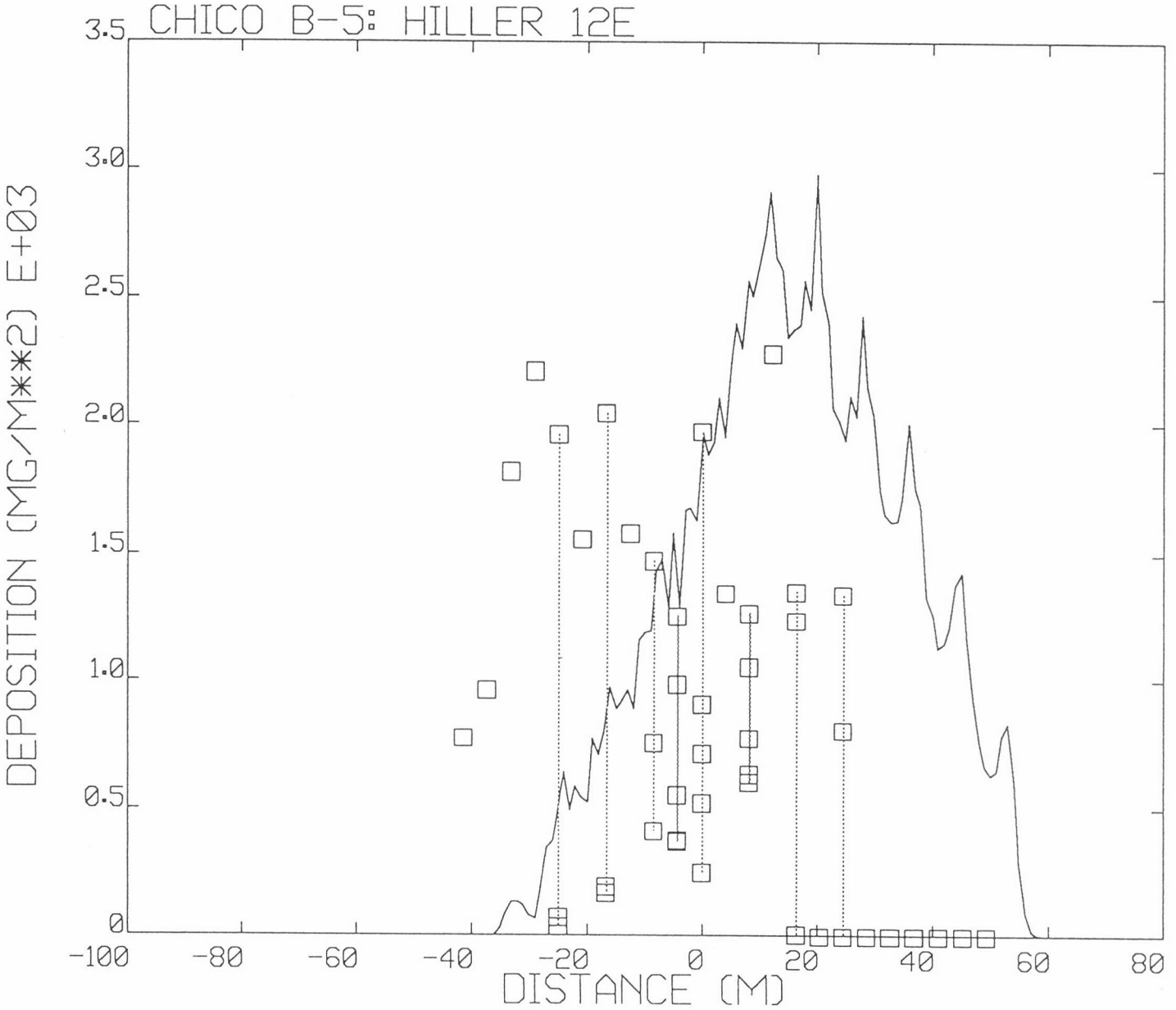

Figure 3-10. Predicted (solid curve) and measured (open squares) ground deposition pattern for run B-5 at Chico (Hiller 12E).

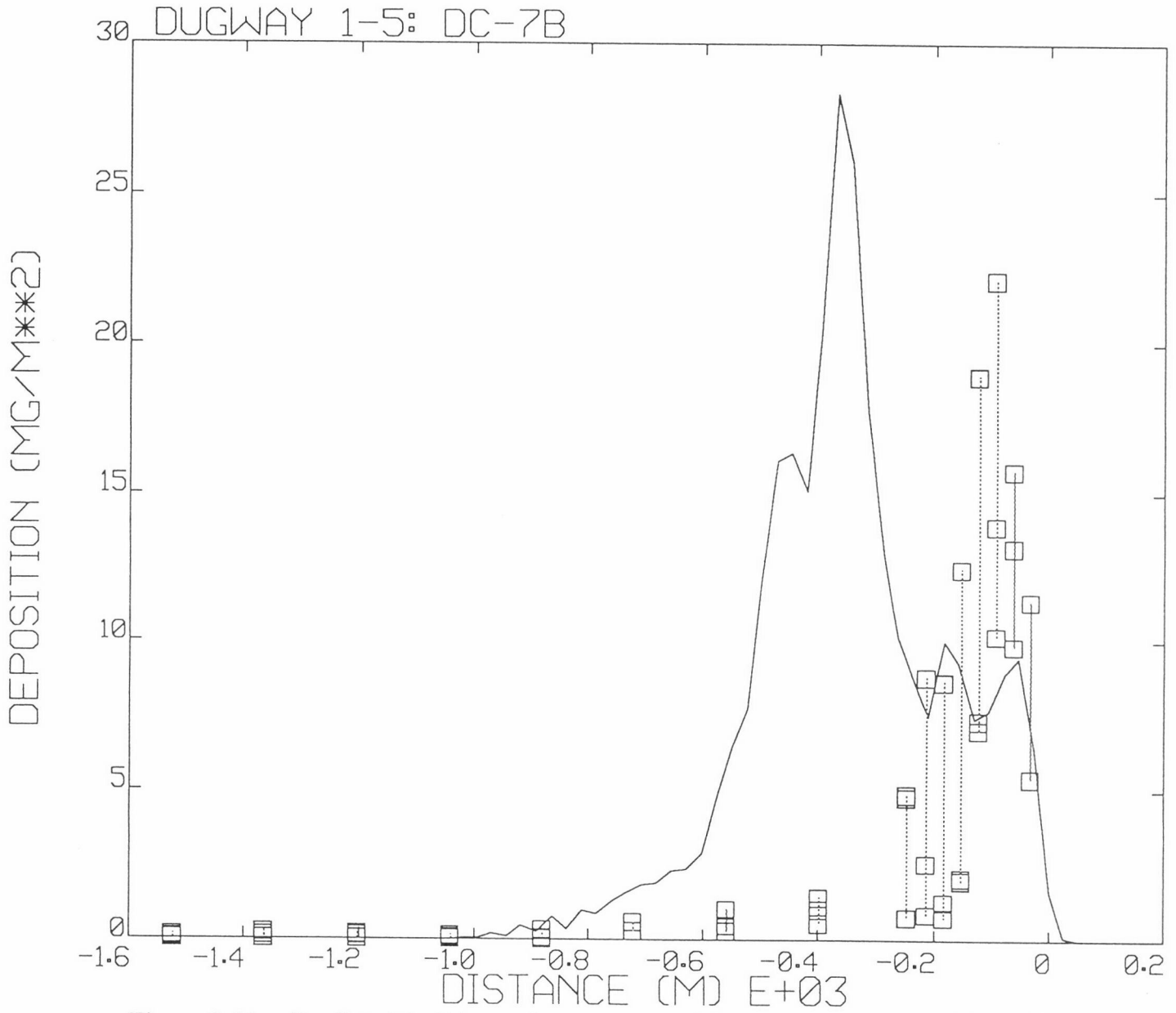

Figure 3-11. Predicted (solid curve) and measured (open squares) ground deposition pattern for run 1-5 at Dugway (DC-7B).

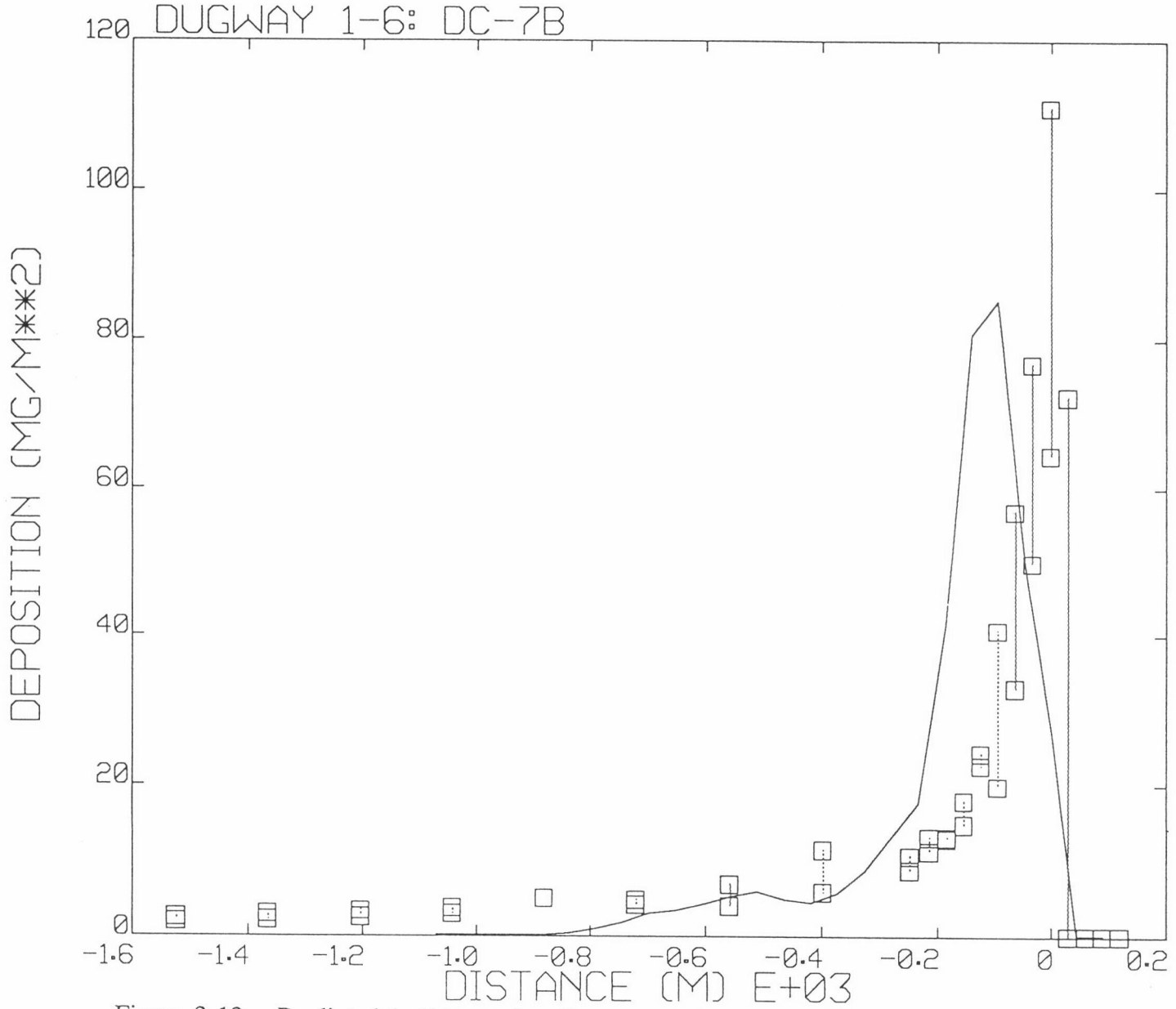

Figure 3-12. Predicted (solid curve) and measured (open squares) ground deposition pattern for run 1-6 at Dugway (DC-7B).

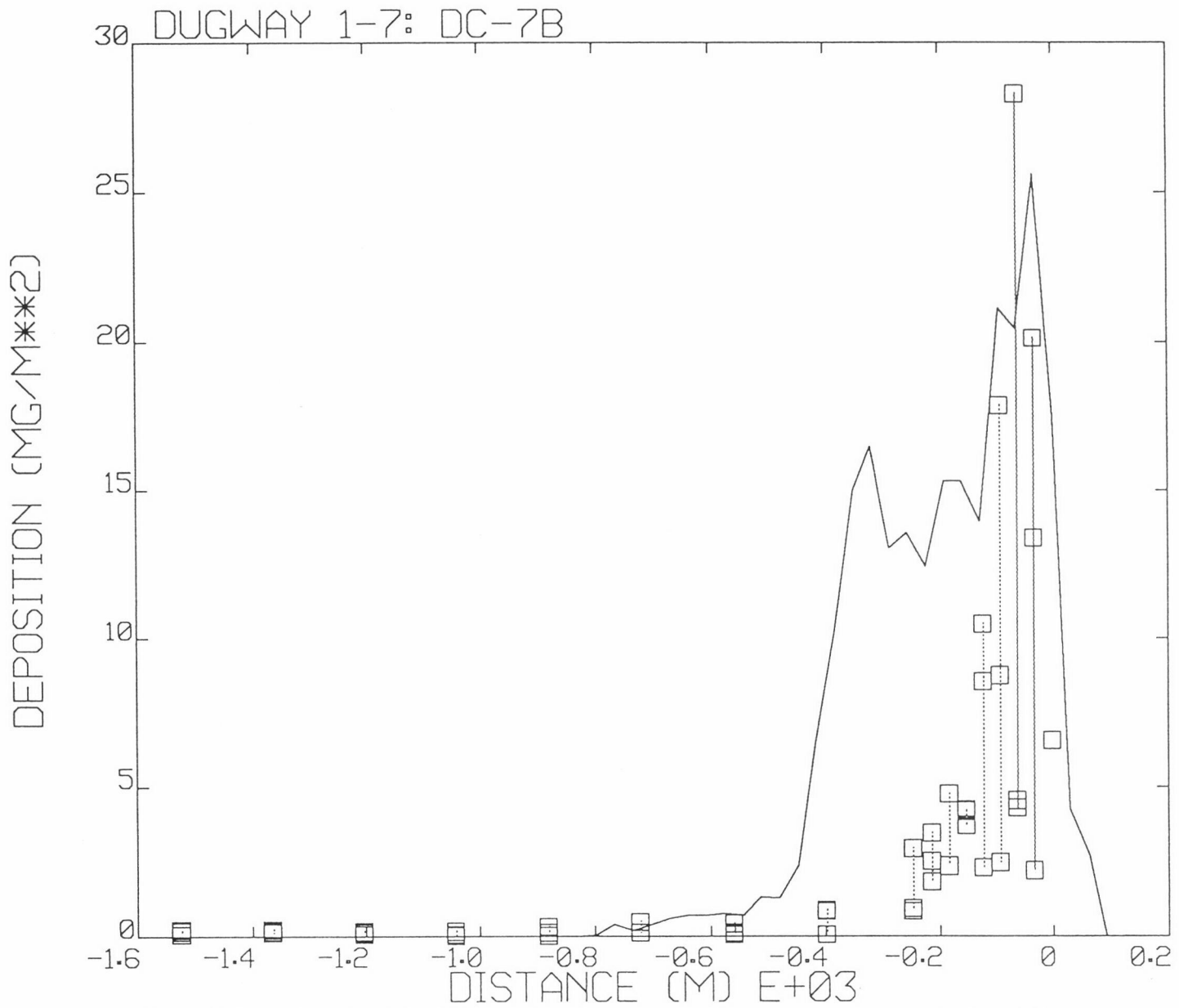

Figure 3-13. Predicted (solid curve) and measured (open squares) ground deposition pattern for run 1-7 at Dugway (DC-7B).

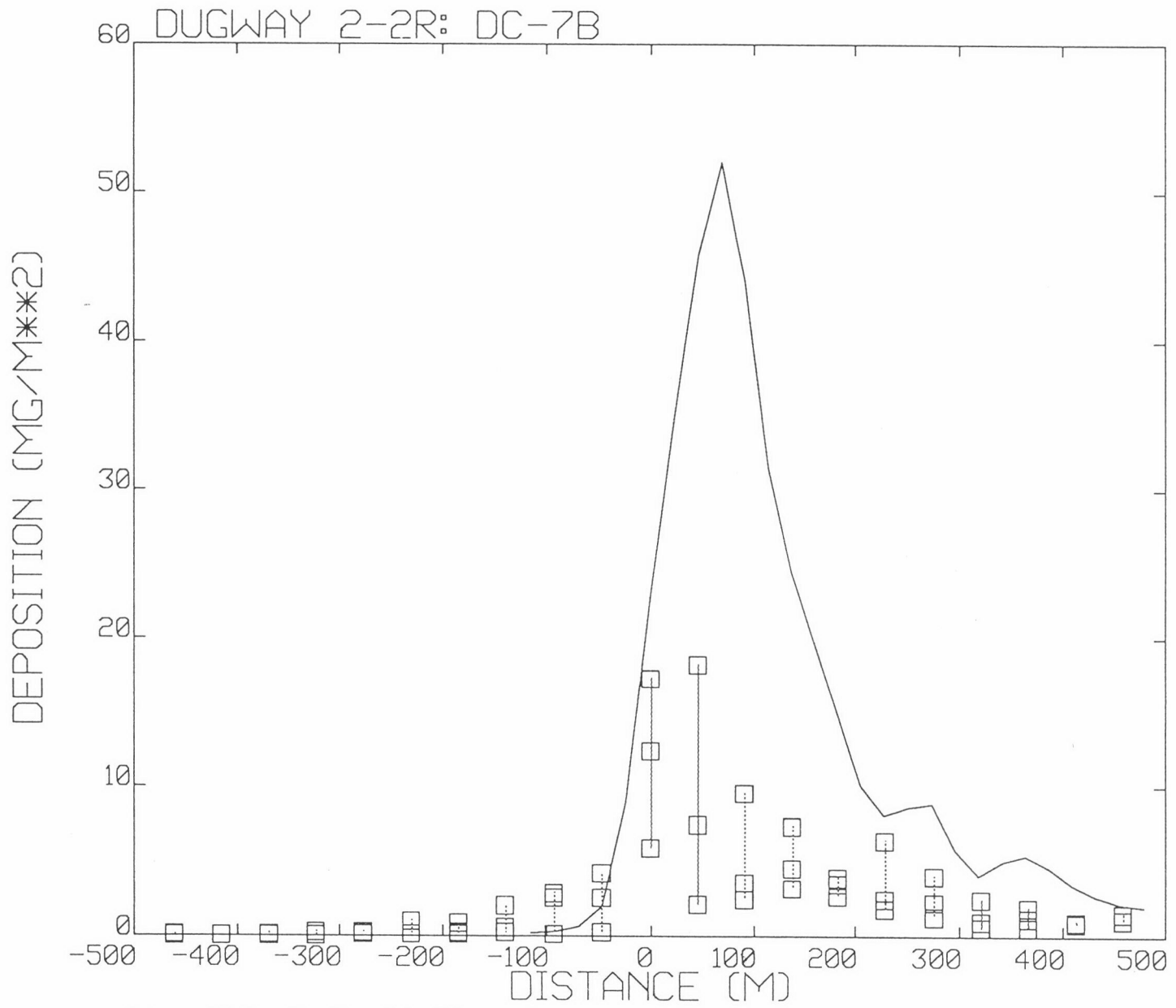

Figure 3-14. Predicted (solid curve) and measured (open squares) ground deposition pattern for run 2-2R at Dugway (DC-7B).

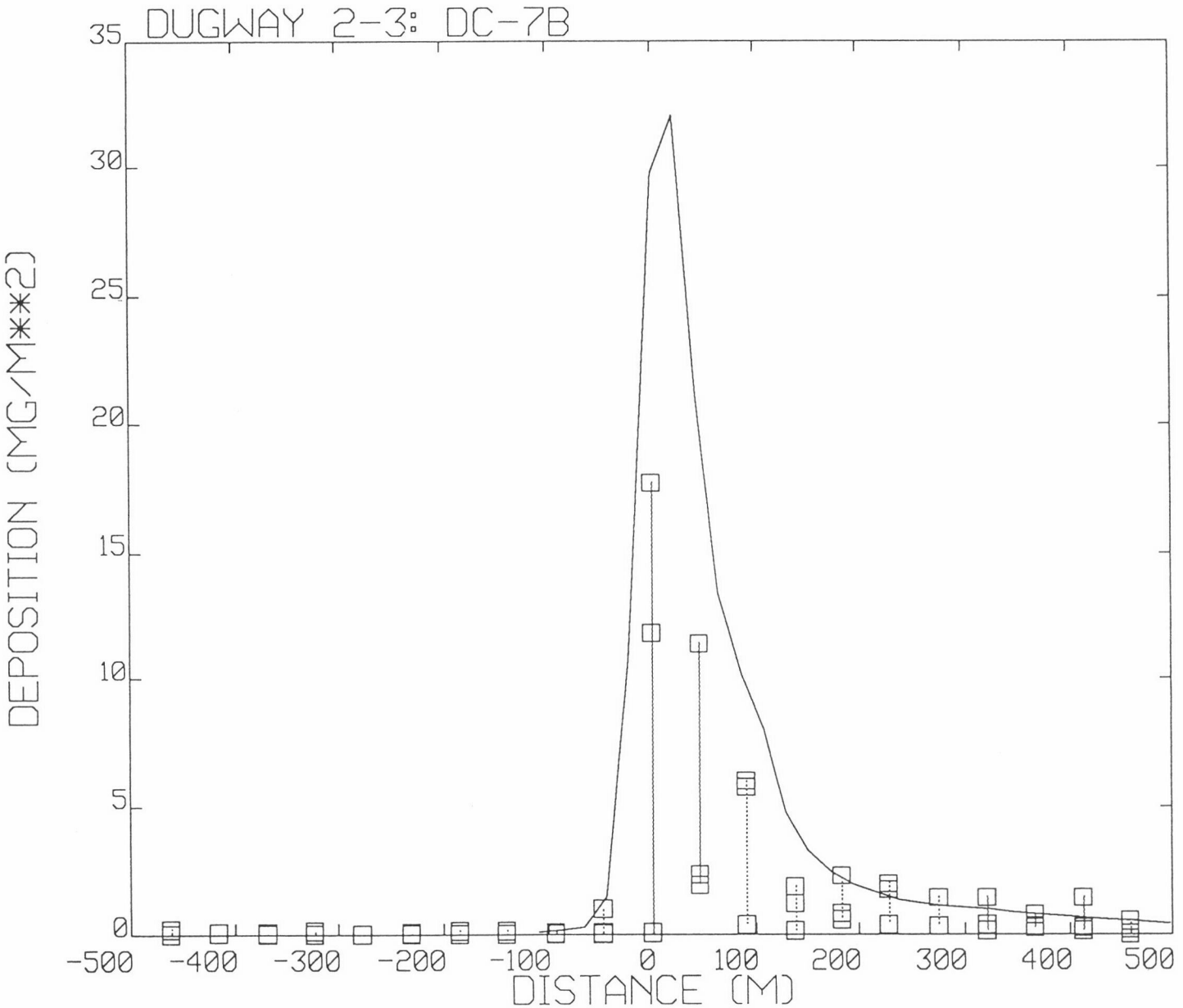

Figure 3-15. Predicted (solid curve) and measured (open squares) ground deposition pattern for run 2-3 at Dugway (DC-7B).

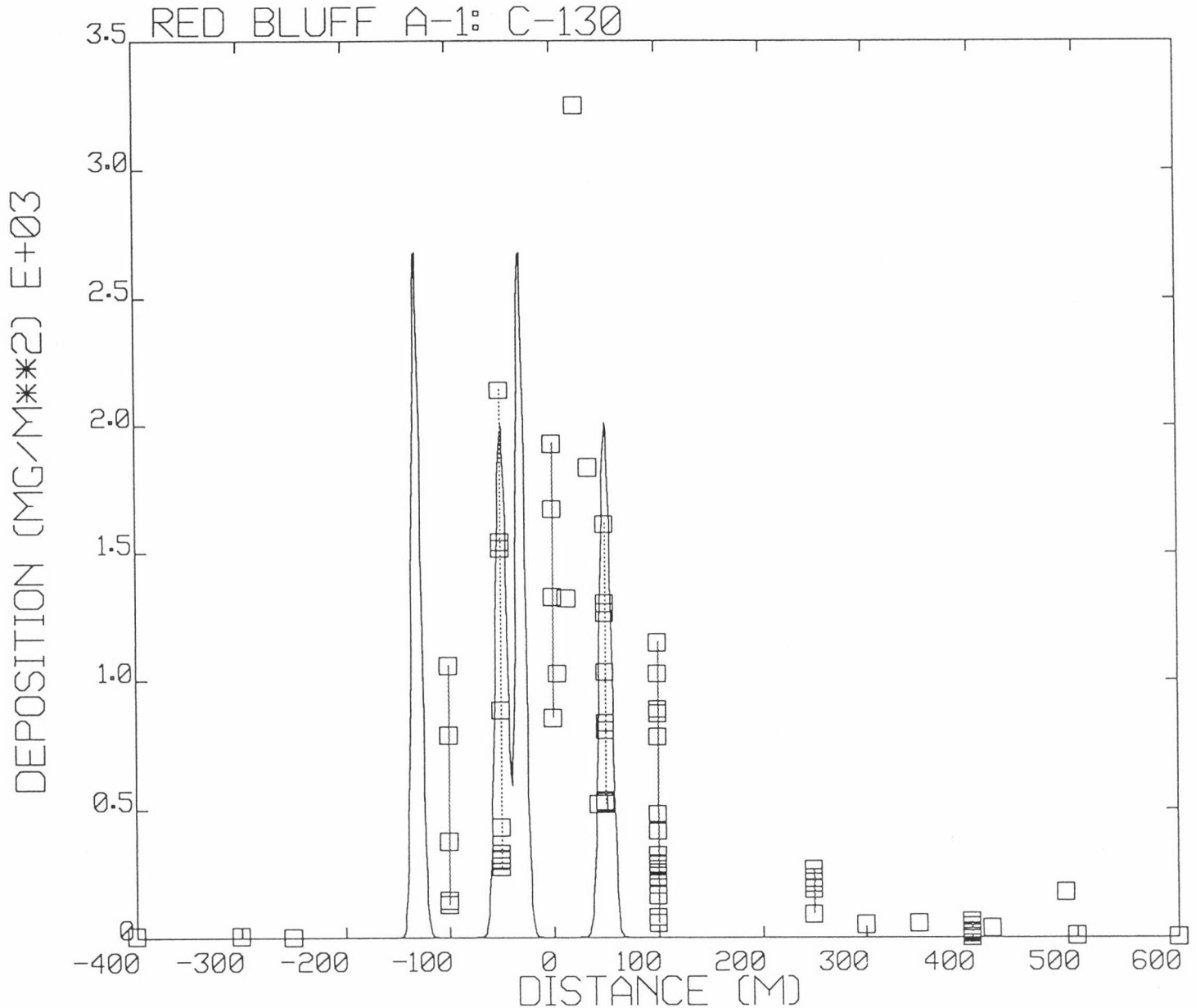

Figure 3-16. Predicted (solid curve) and measured (open squares) ground deposition pattern for run A-1 at Red Bluff (C-130).

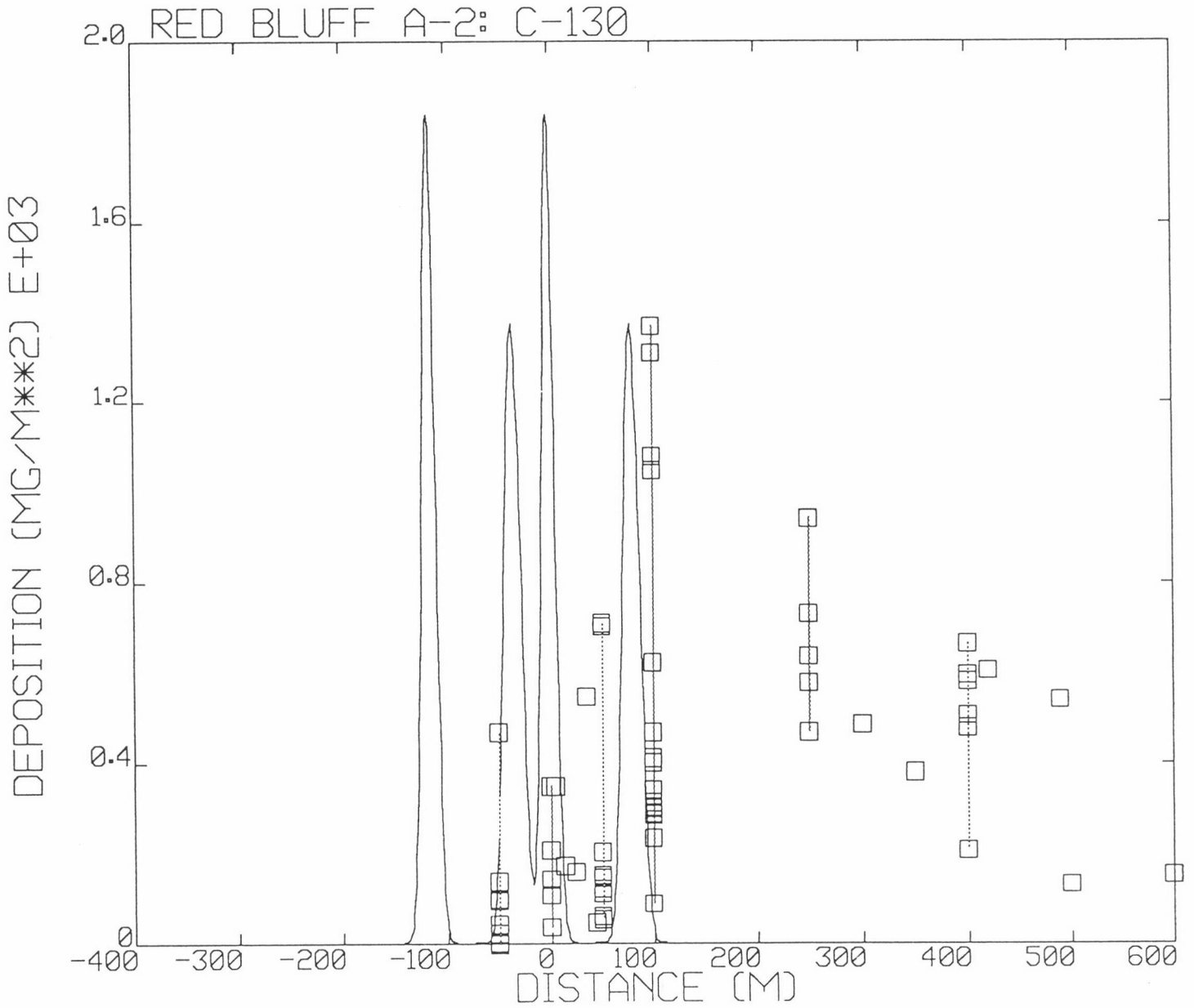

Figure 3-17. Predicted (solid curve) and measured (open squares) ground deposition pattern for run A-2 at Red Bluff (C-130).

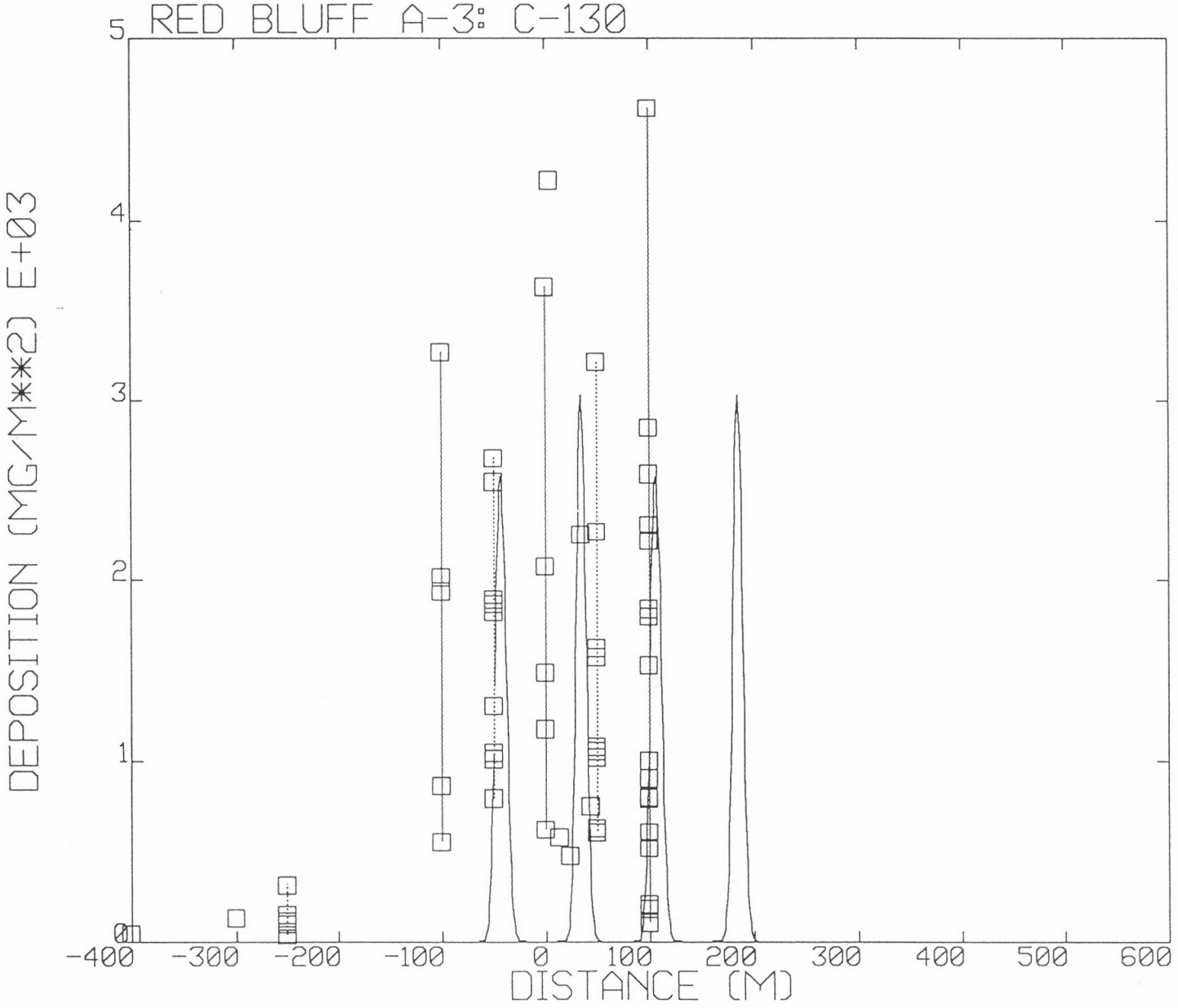

Figure 3-18. Predicted (solid curve) and measured (open squares) ground deposition pattern for run A-3 at Red Bluff (C-130).

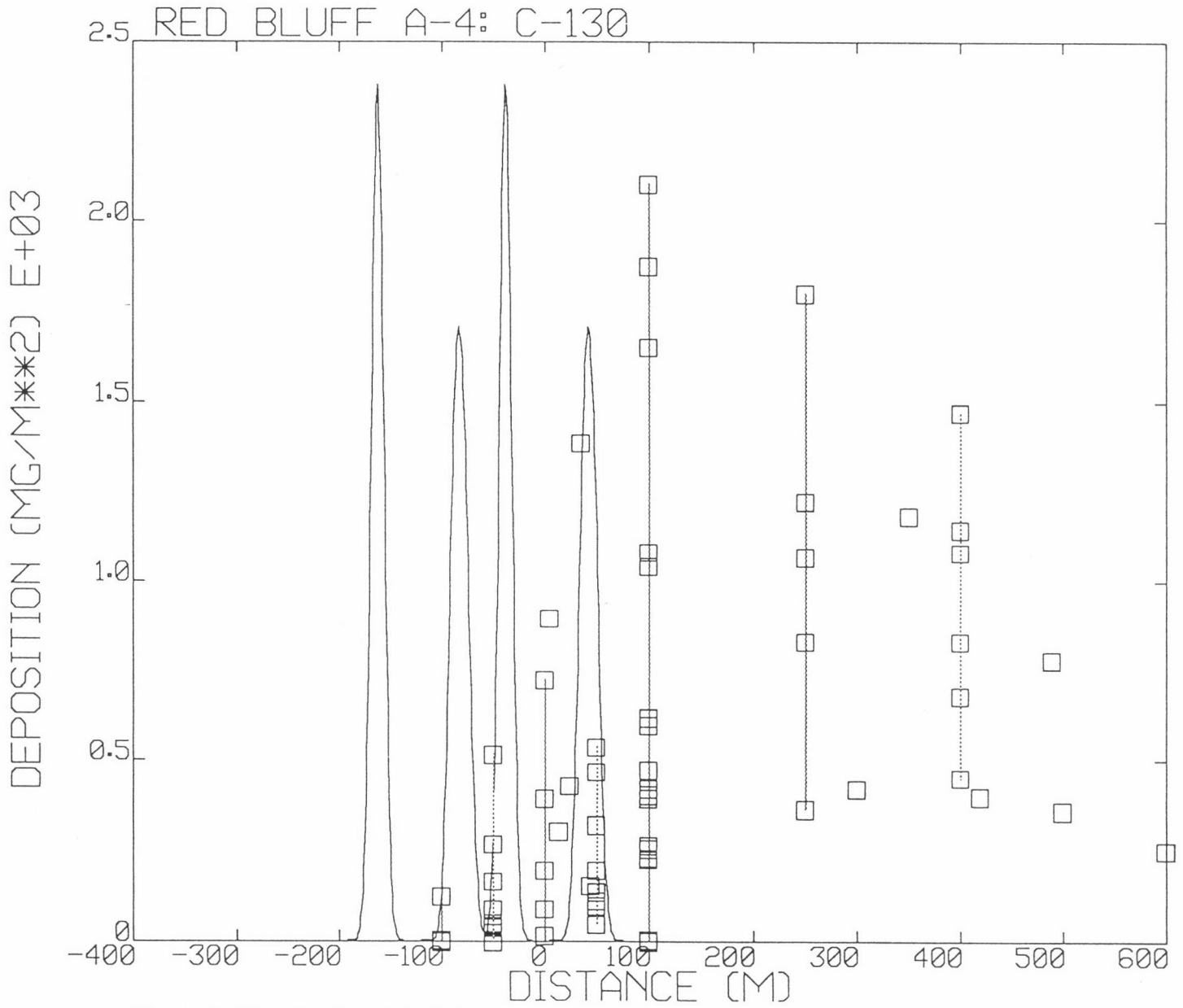

Figure 3-19. Predicted (solid curve) and measured (open squares) ground deposition pattern for run A-4 at Red Bluff (C-130).

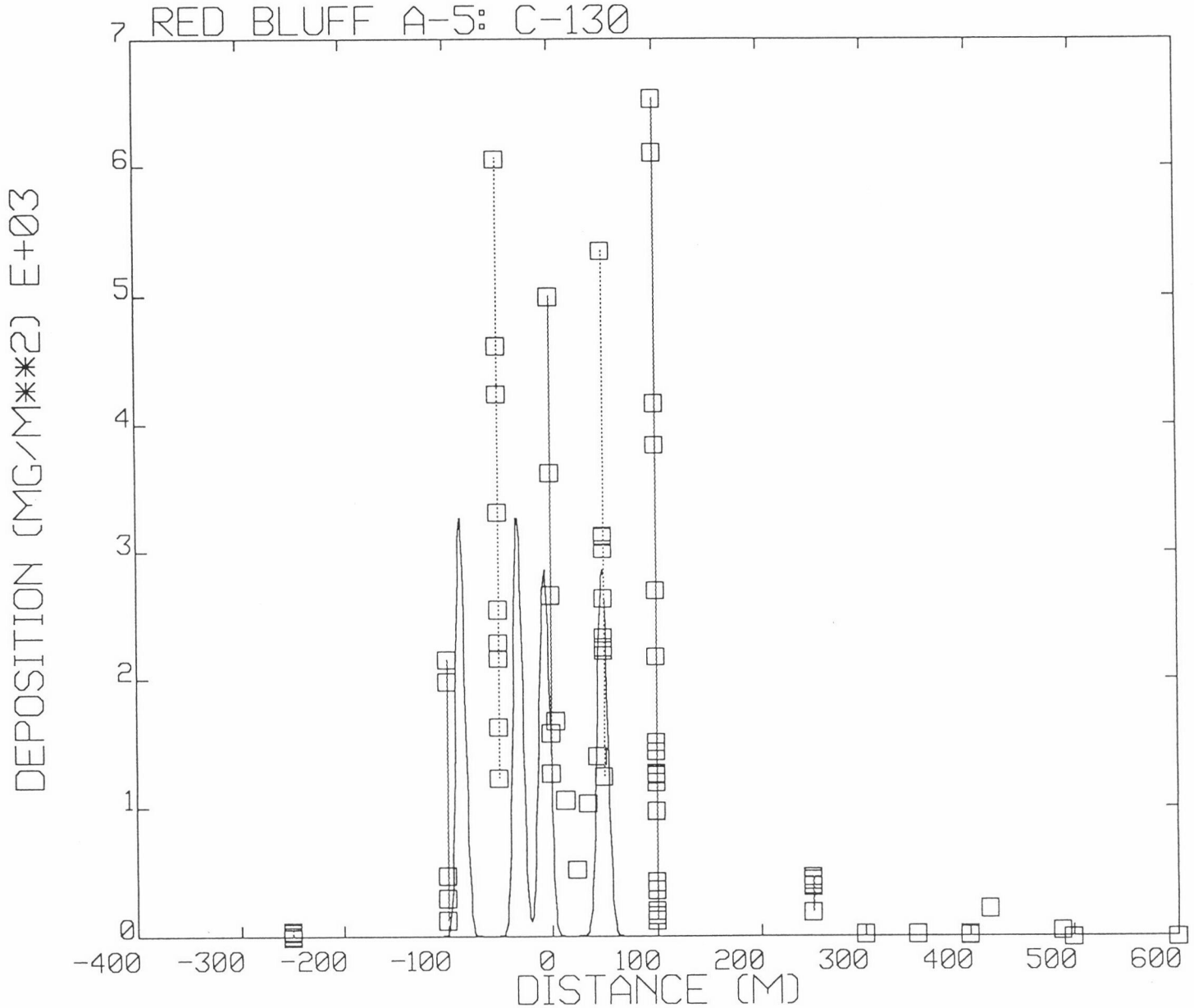

Figure 3-20. Predicted (solid curve) and measured (open squares) ground deposition pattern for run A-5 at Red Bluff (C-130).

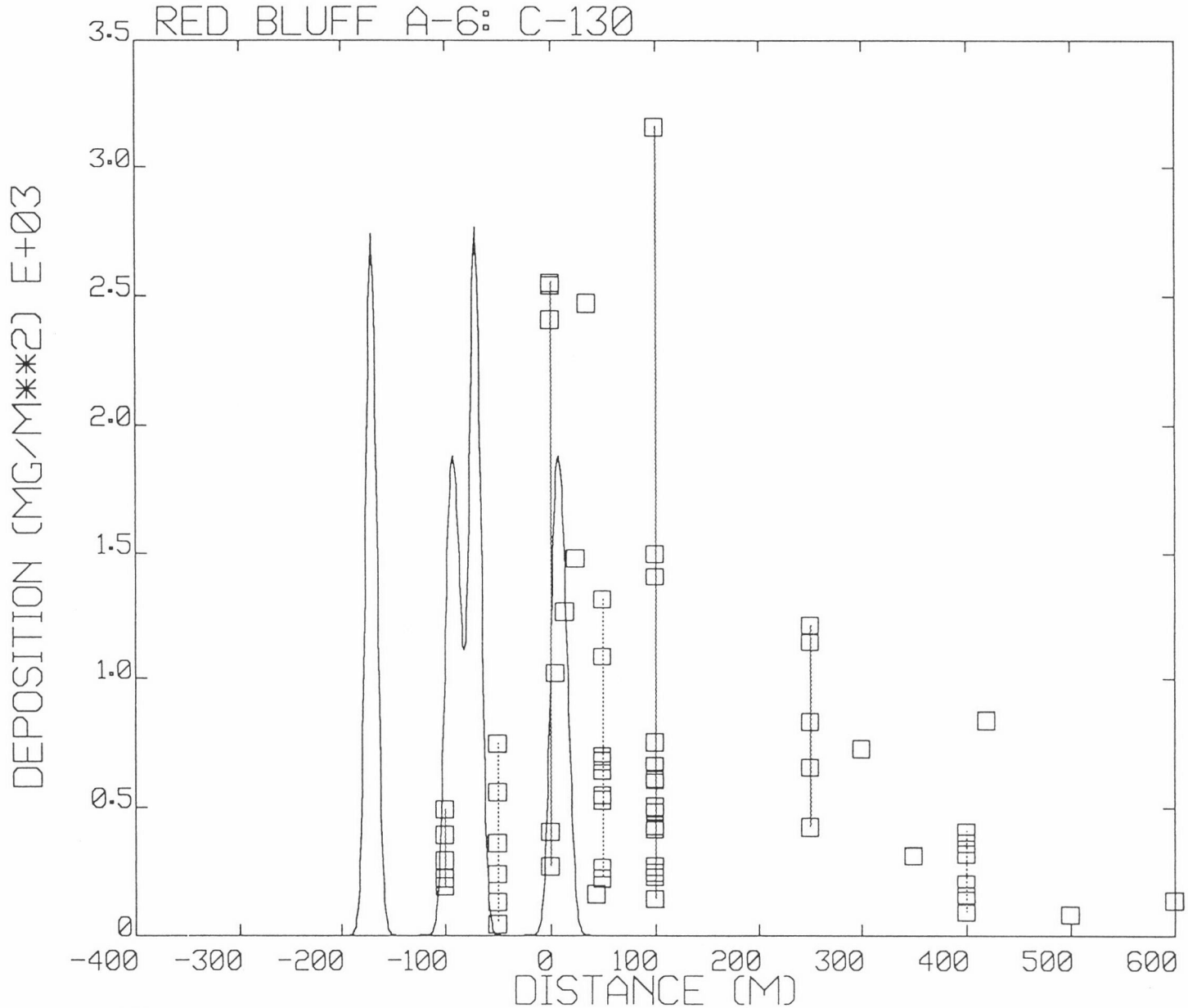

Figure 3-21. Predicted (solid curve) and measured (open squares) ground deposition pattern for run A-6 at Red Bluff (C-130).

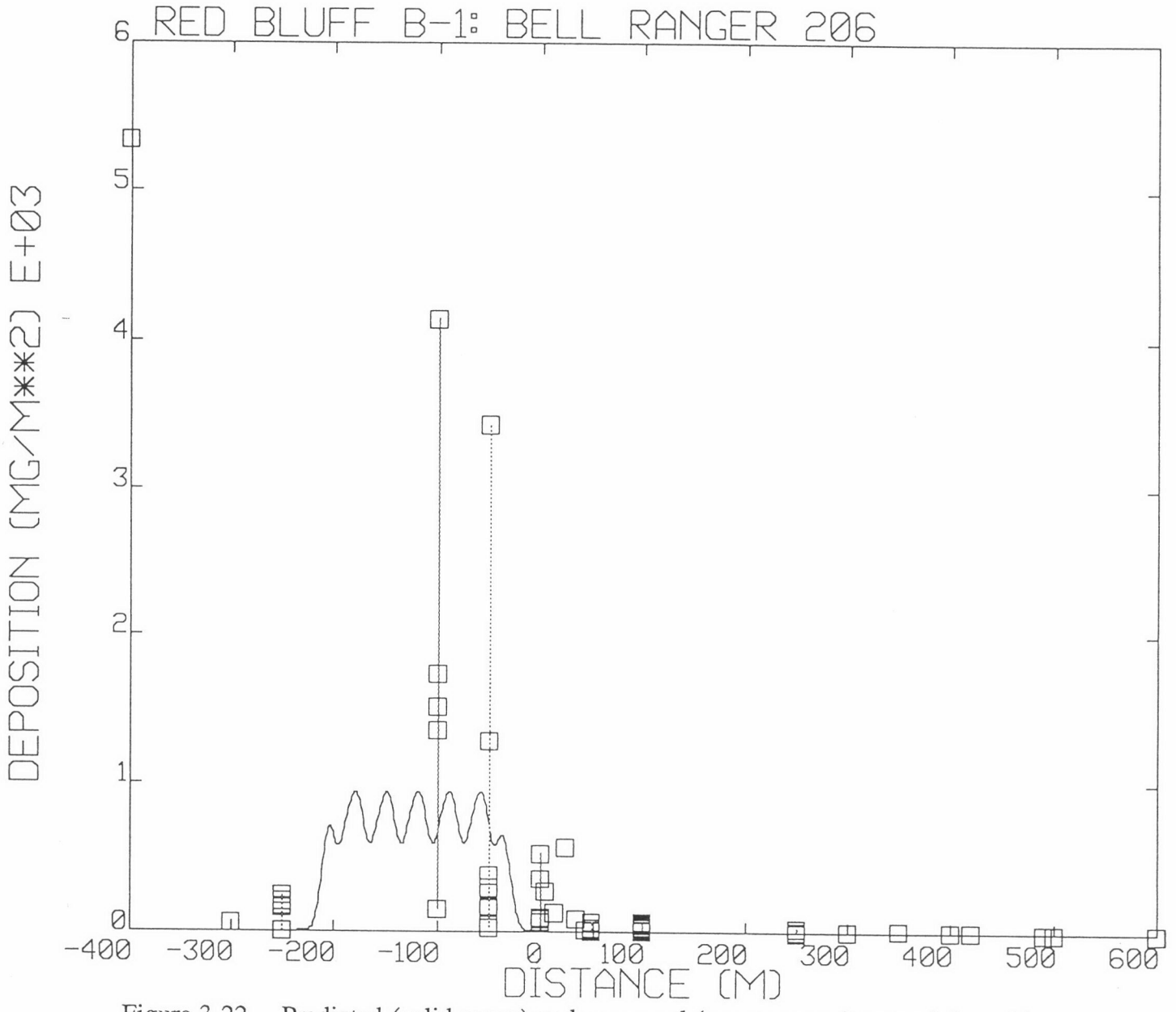

Figure 3-22. Predicted (solid curve) and measured (open squares) ground deposition pattern for run B-1 at Red Bluff (Bell Ranger 206).

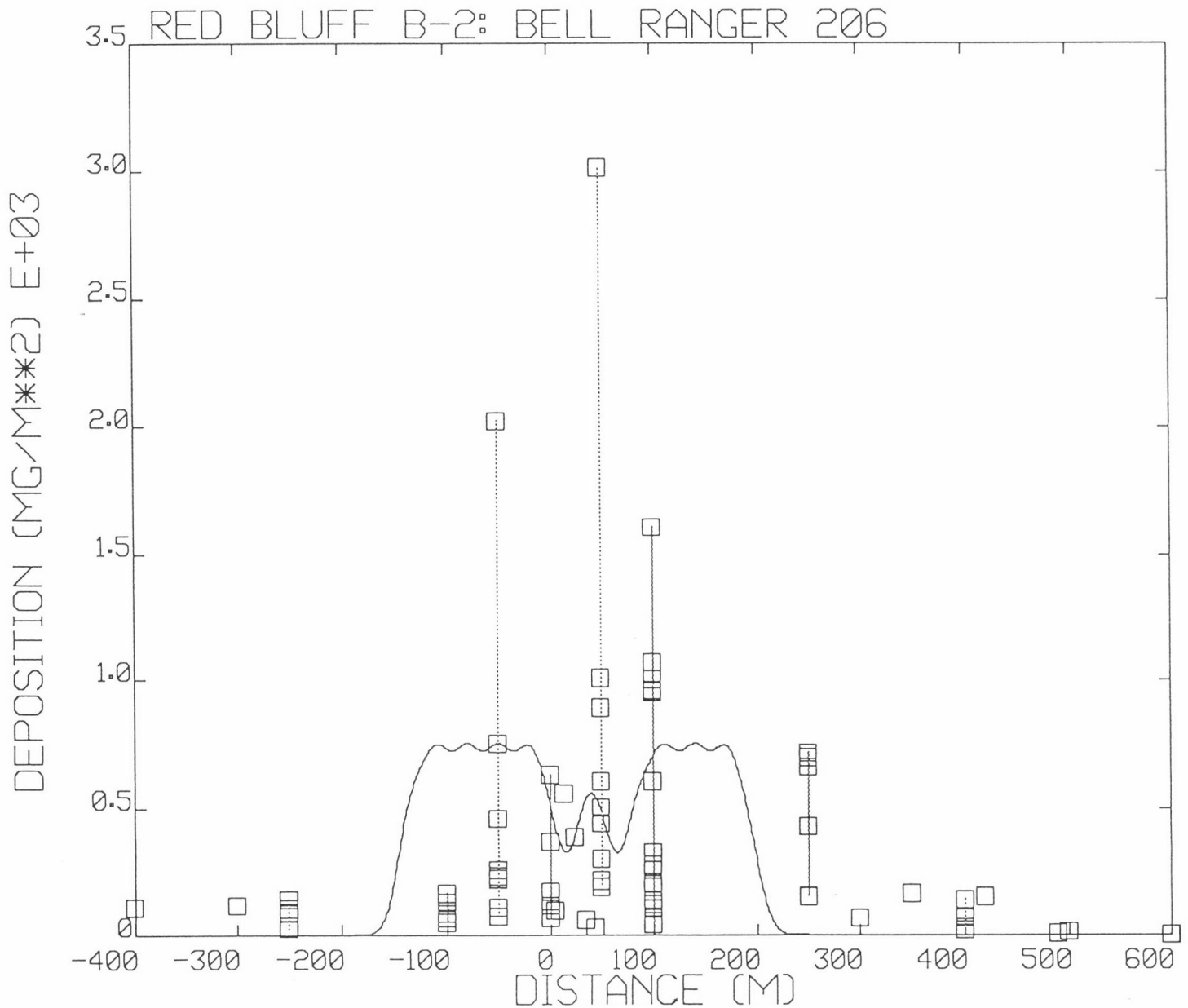

Figure 3-23. Predicted (solid curve) and measured (open squares) ground deposition pattern for run B-2 at Red Bluff (Bell Ranger 206).

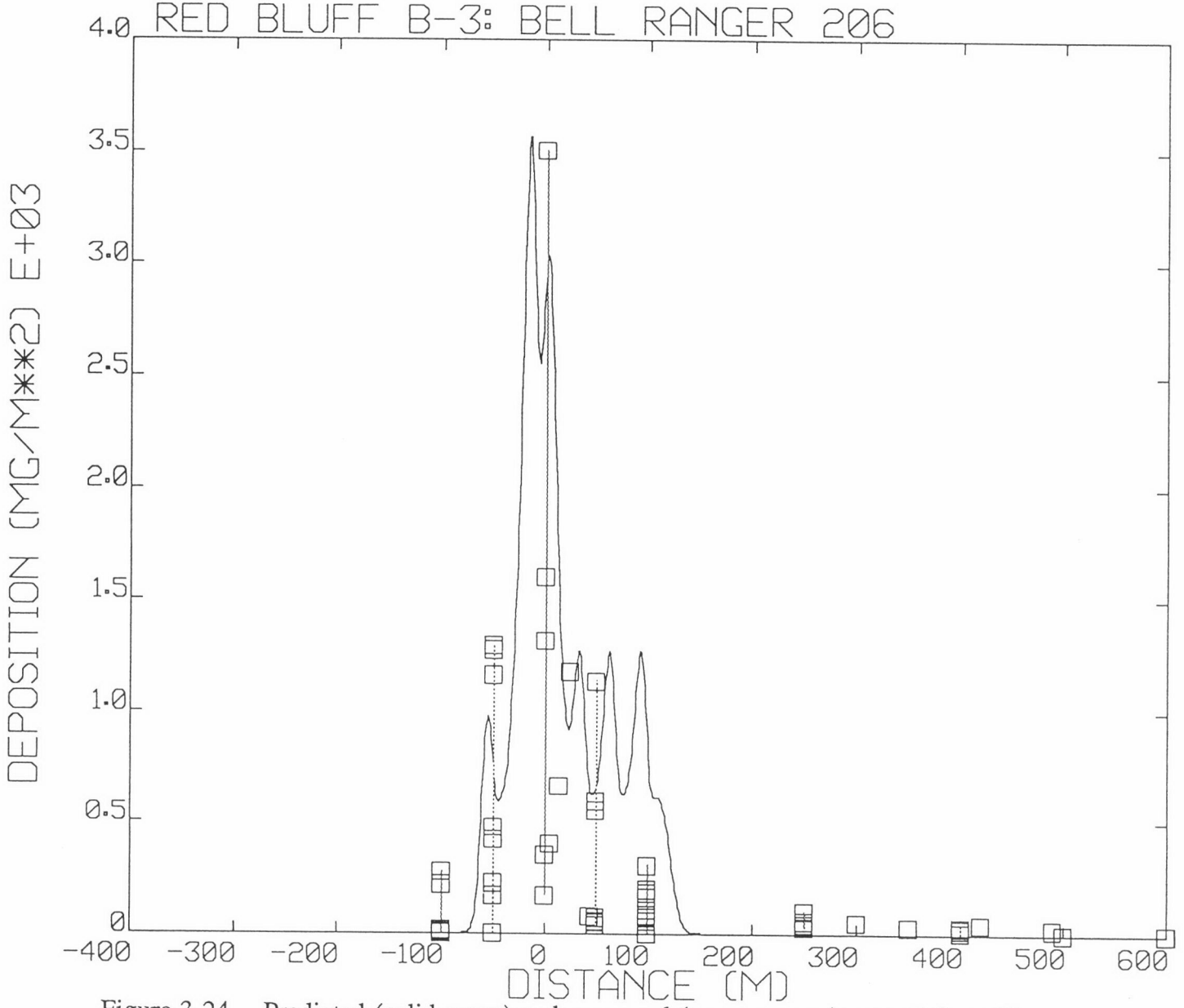

Figure 3-24. Predicted (solid curve) and measured (open squares) ground deposition pattern for run B-3 at Red Bluff (Bell Ranger 206). The data is divided by a factor of 8.3 to match the spray emission rate and correct for moisture on the cards.

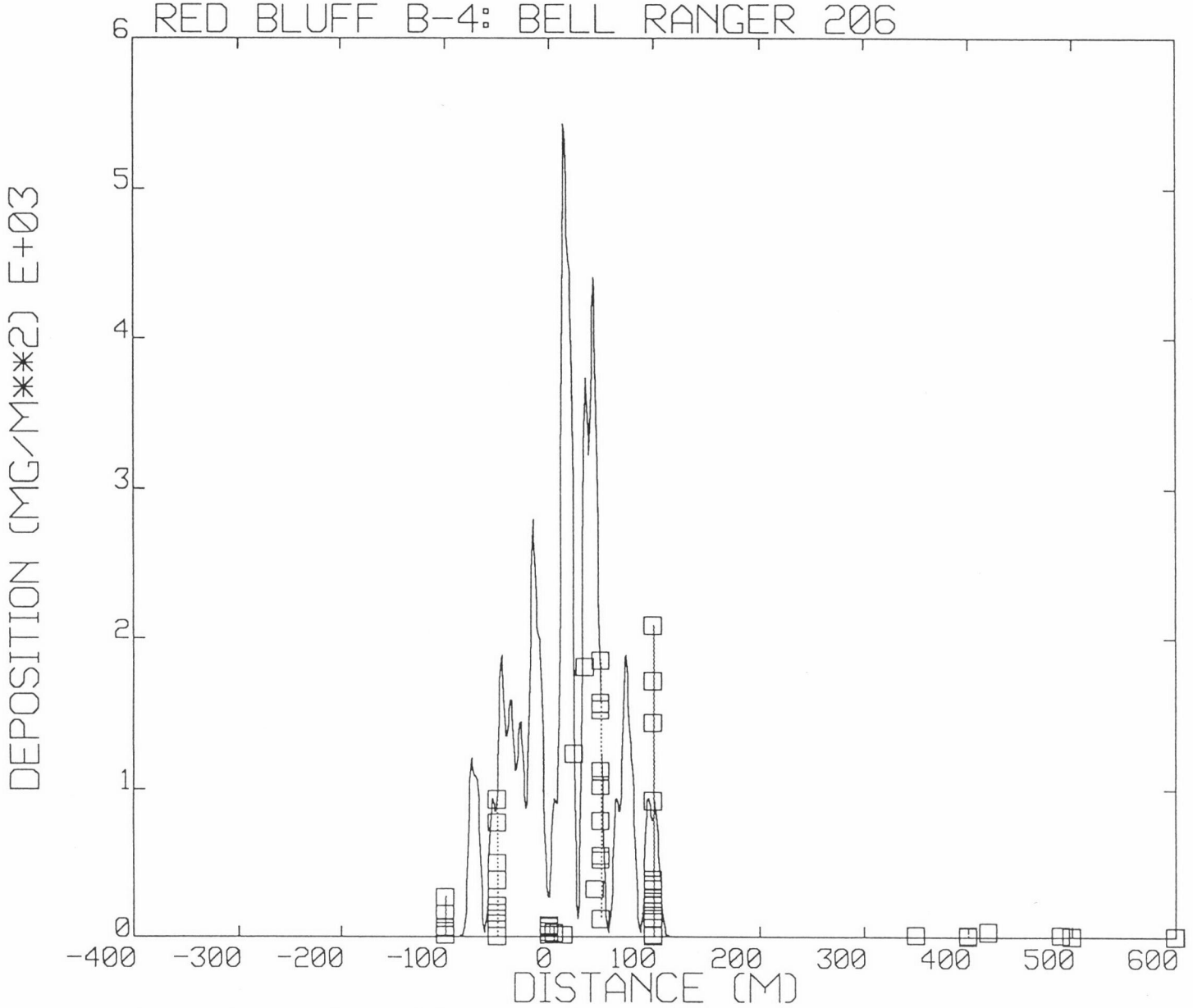

Figure 3-25. Predicted (solid curve) and measured (open squares) ground deposition pattern for run B-4 at Red Bluff (Bell Ranger 206). The data is divided by a factor of 10.6 to match the spray emission rate and correct for moisture on the cards.

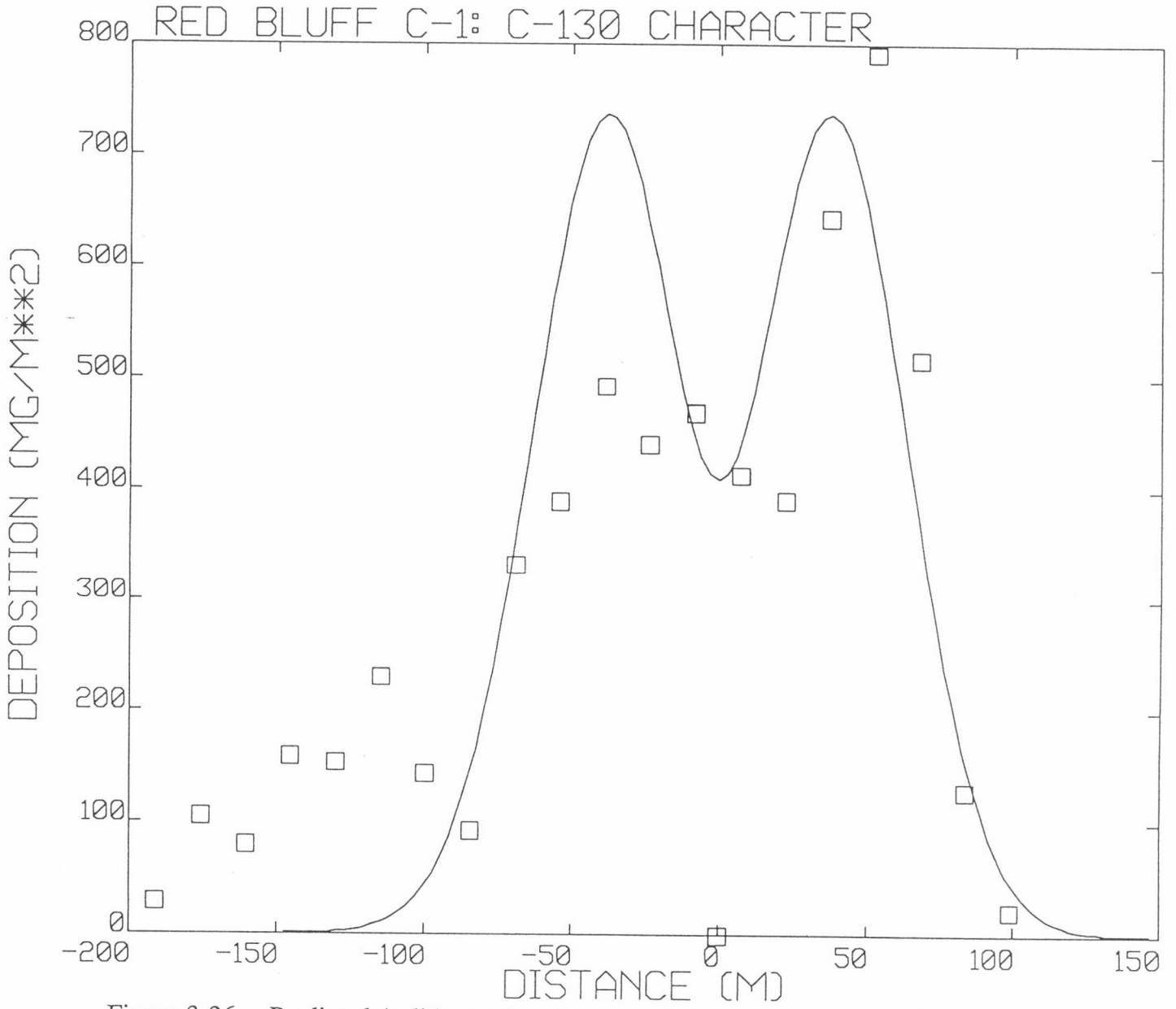

Figure 3-26. Predicted (solid curve) and measured (open squares) ground deposition pattern for the Red Bluff (C-130) characterization run. The data is divided by a factor of 1.9 to match the spray emission rate.

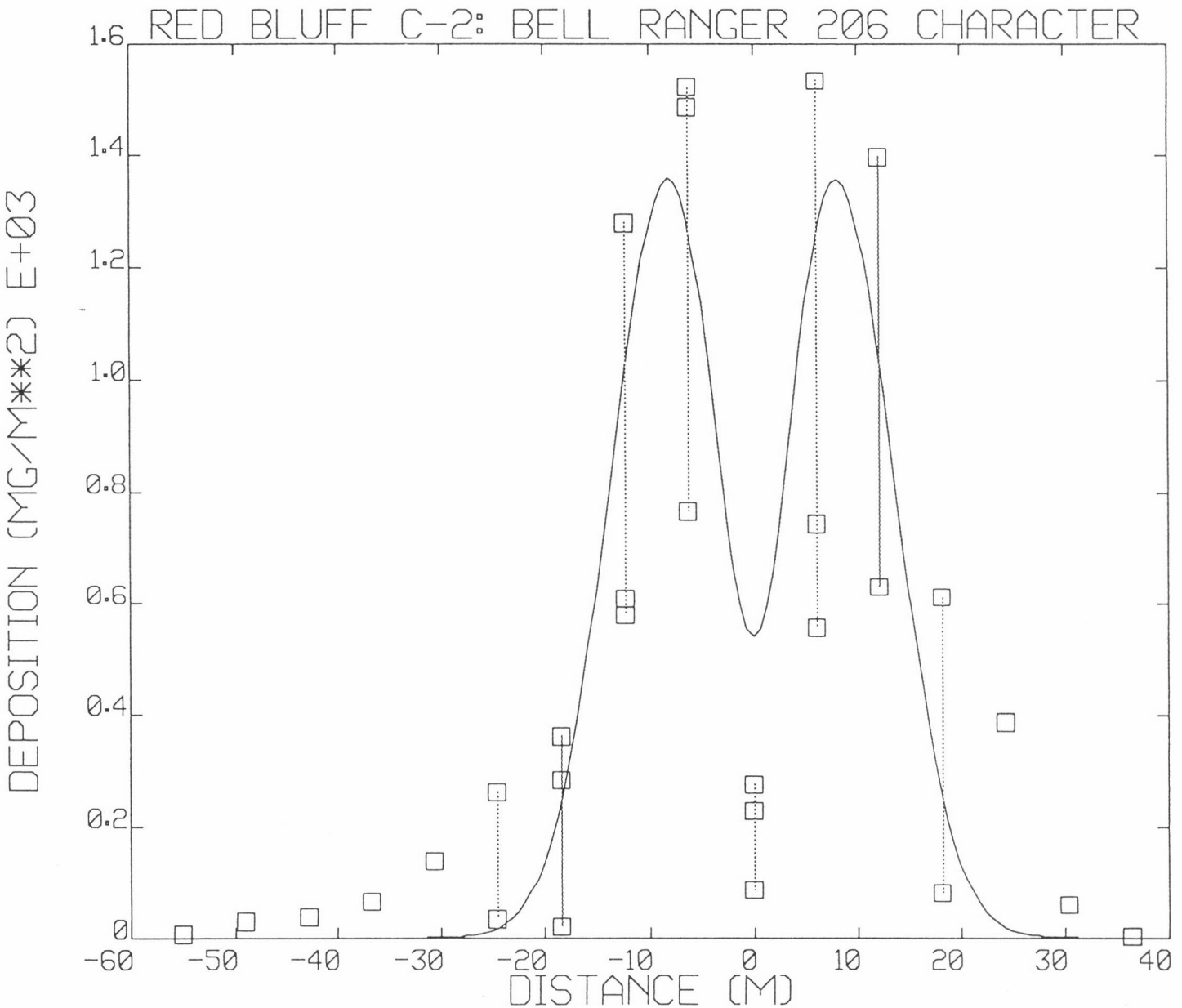

Figure 3-27. Predicted (solid curve) and measured (open squares) ground deposition pattern for the Red Bluff (Bell Ranger 206) characterization runs. The data is divided by a factor of 7.7 to match the spray emission rate.

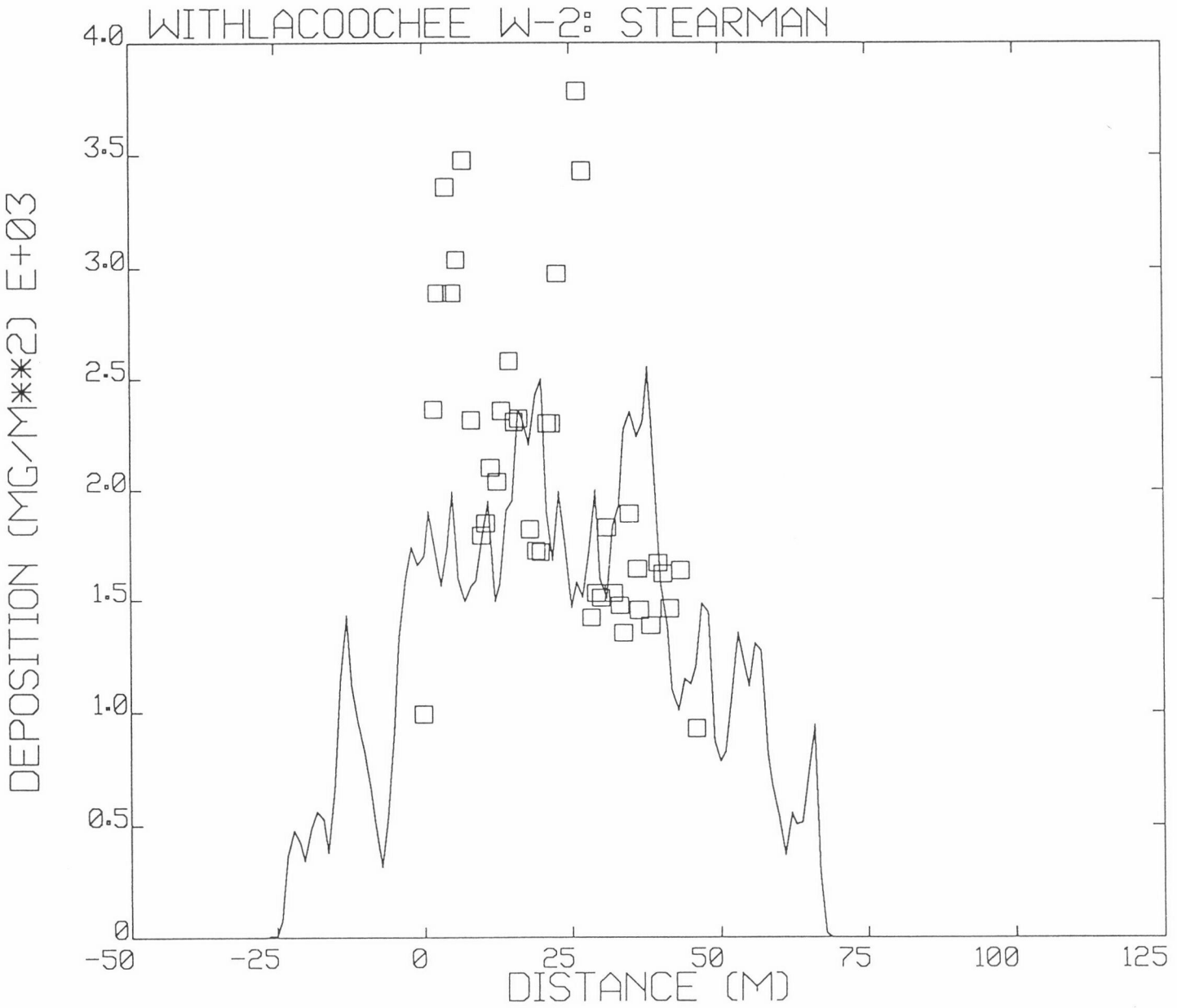

Figure 3-28. Predicted (solid curve) and averaged measured (open squares) ground deposition pattern for run W-2 at Withlacoochee (Stearman).

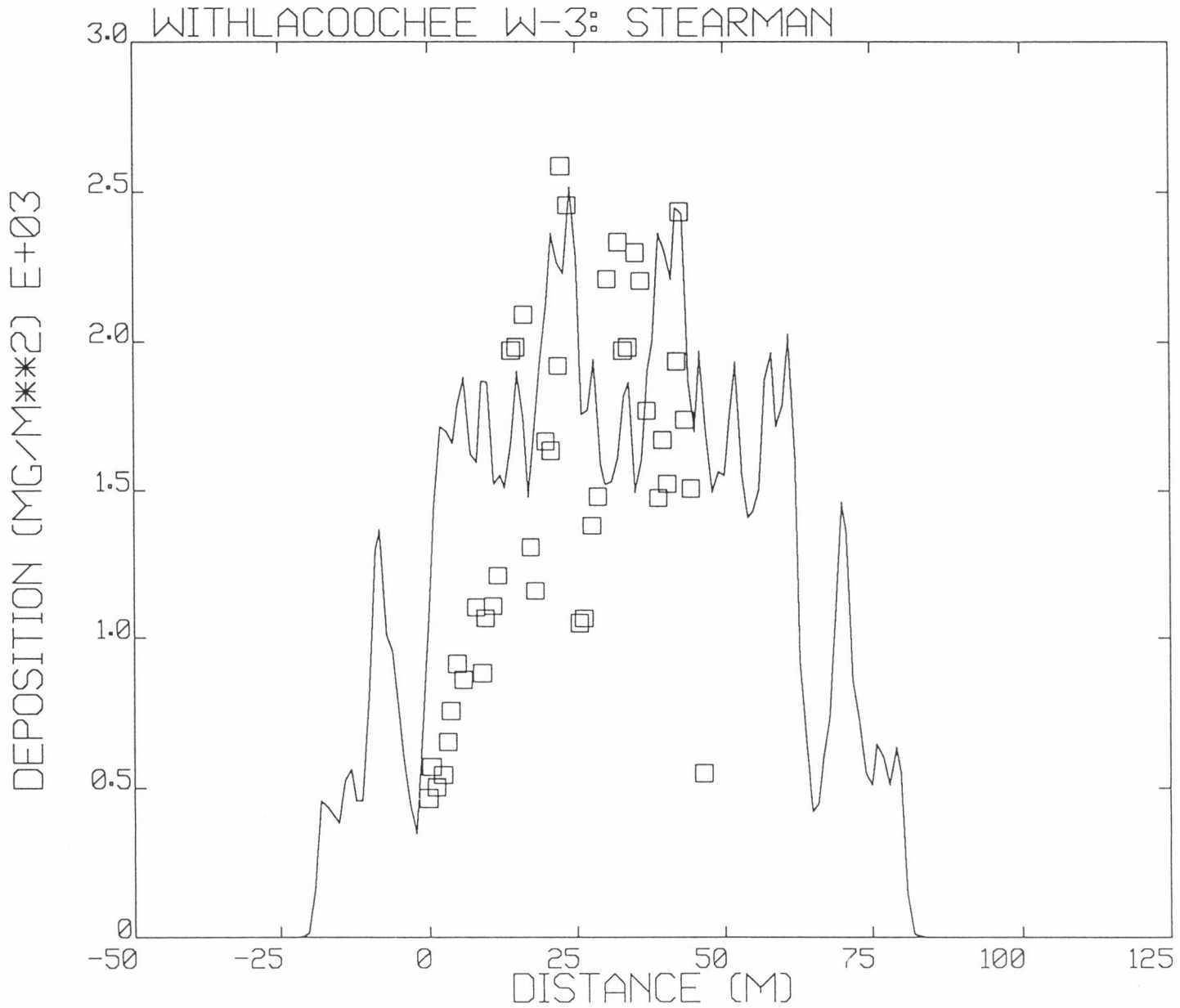

Figure 3-29. Predicted (solid curve) and averaged measured (open squares) ground deposition pattern for run W-3 at Withlacoochee (Stearman).

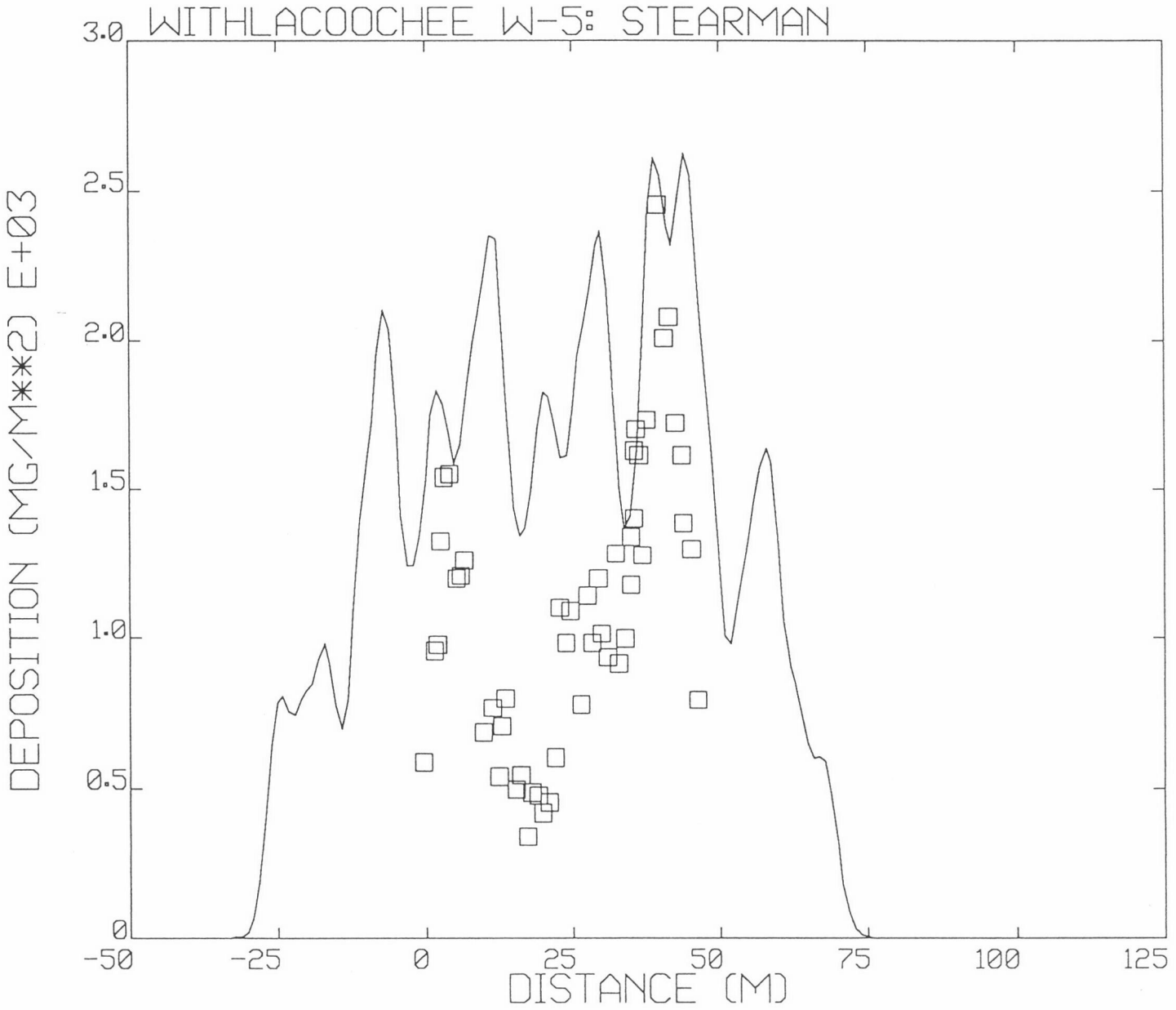

Figure 3-30. Predicted (solid curve) and averaged measured (open squares) ground deposition pattern for run W-5 at Withlacoochee (Stearman).

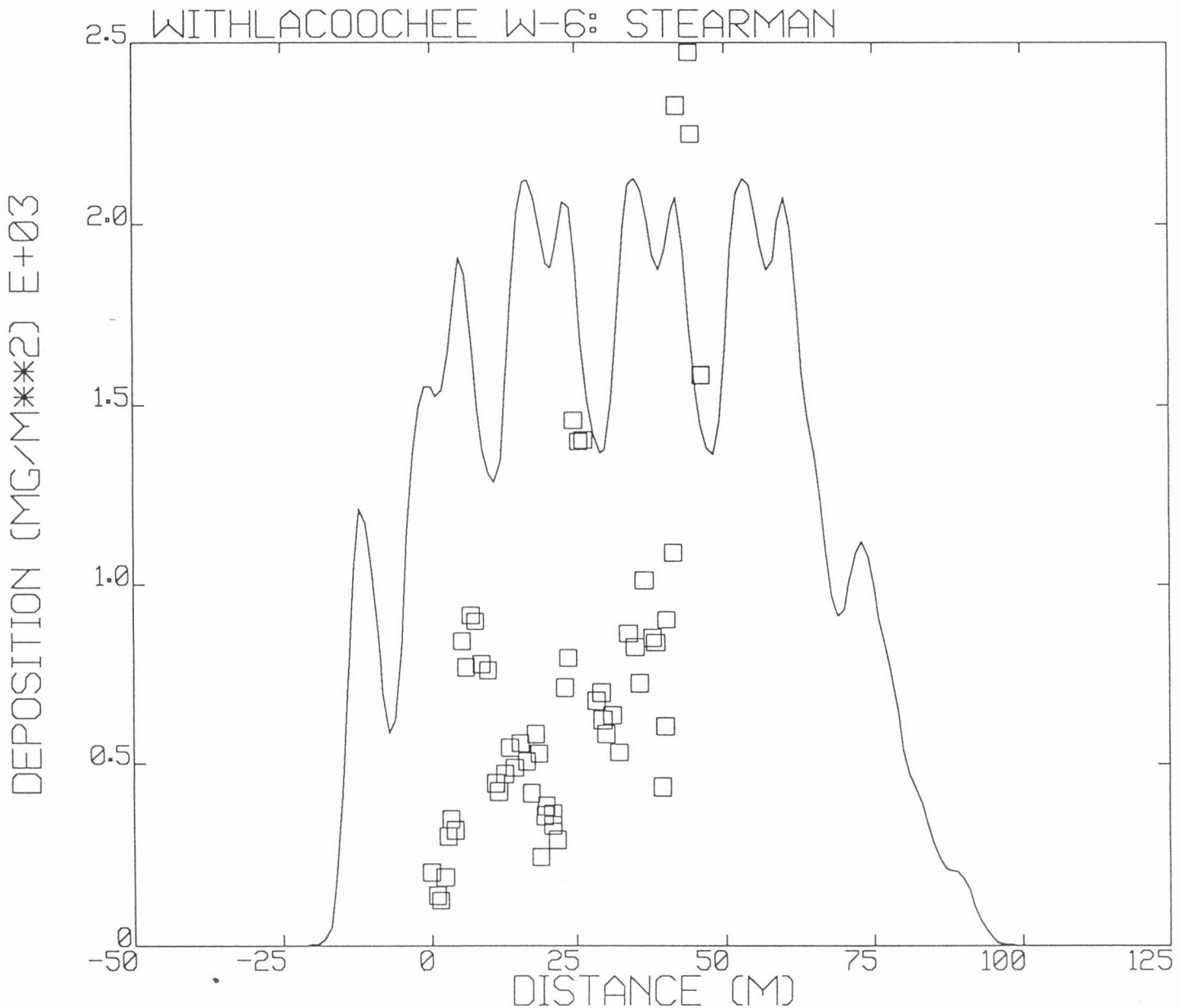

Figure 3-31. Predicted (solid curve) and averaged measured (open squares) ground deposition pattern for run W-6 at Withlacoochee (Stearman).

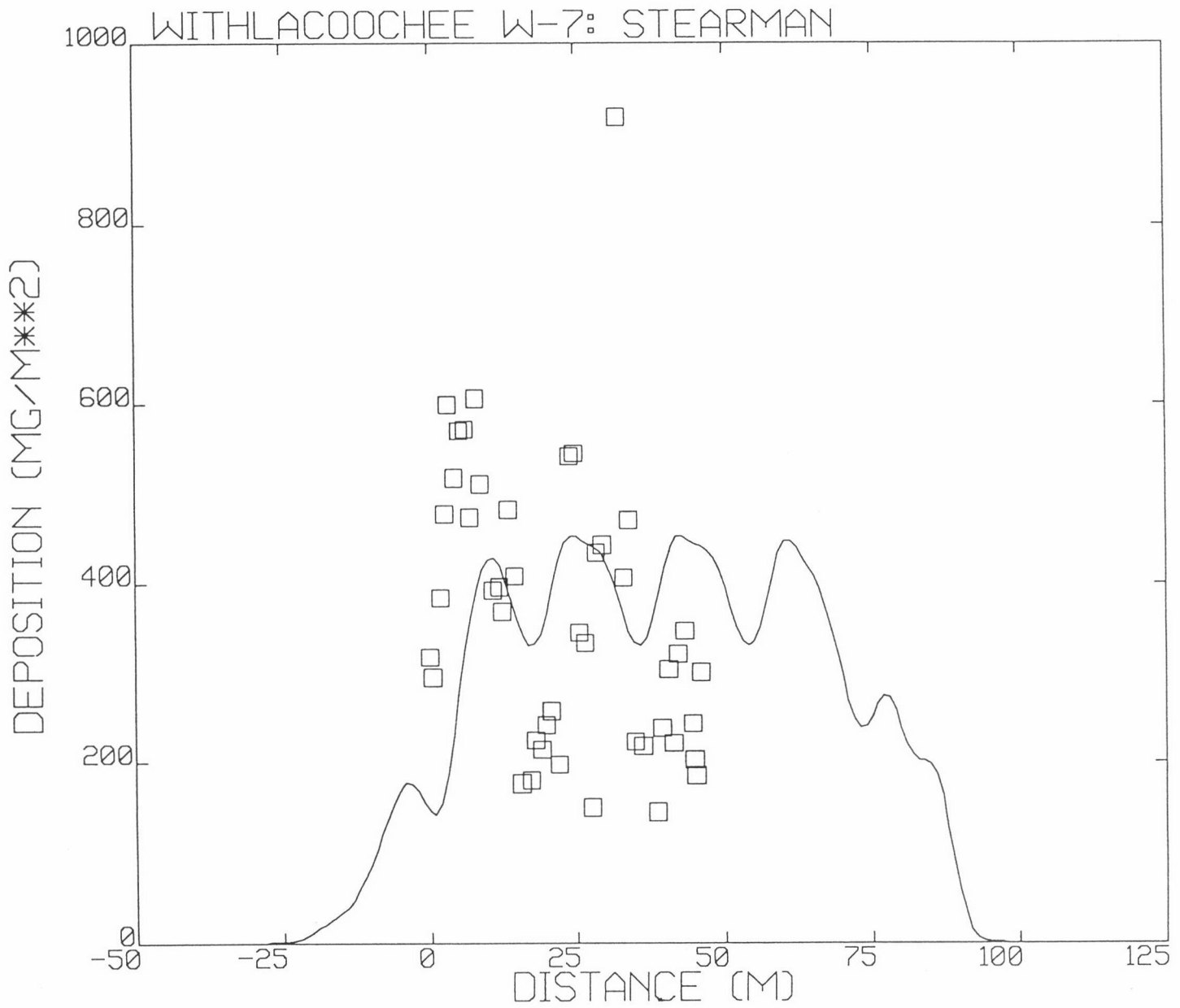

Figure 3-32. Predicted (solid curve) and averaged measured (open squares) ground deposition pattern for run W-7 at Withlacoochee (Stearman). Spray emission rate has been adjusted to 6.3 gal/min consistent with the spray emission rate of run W-6.

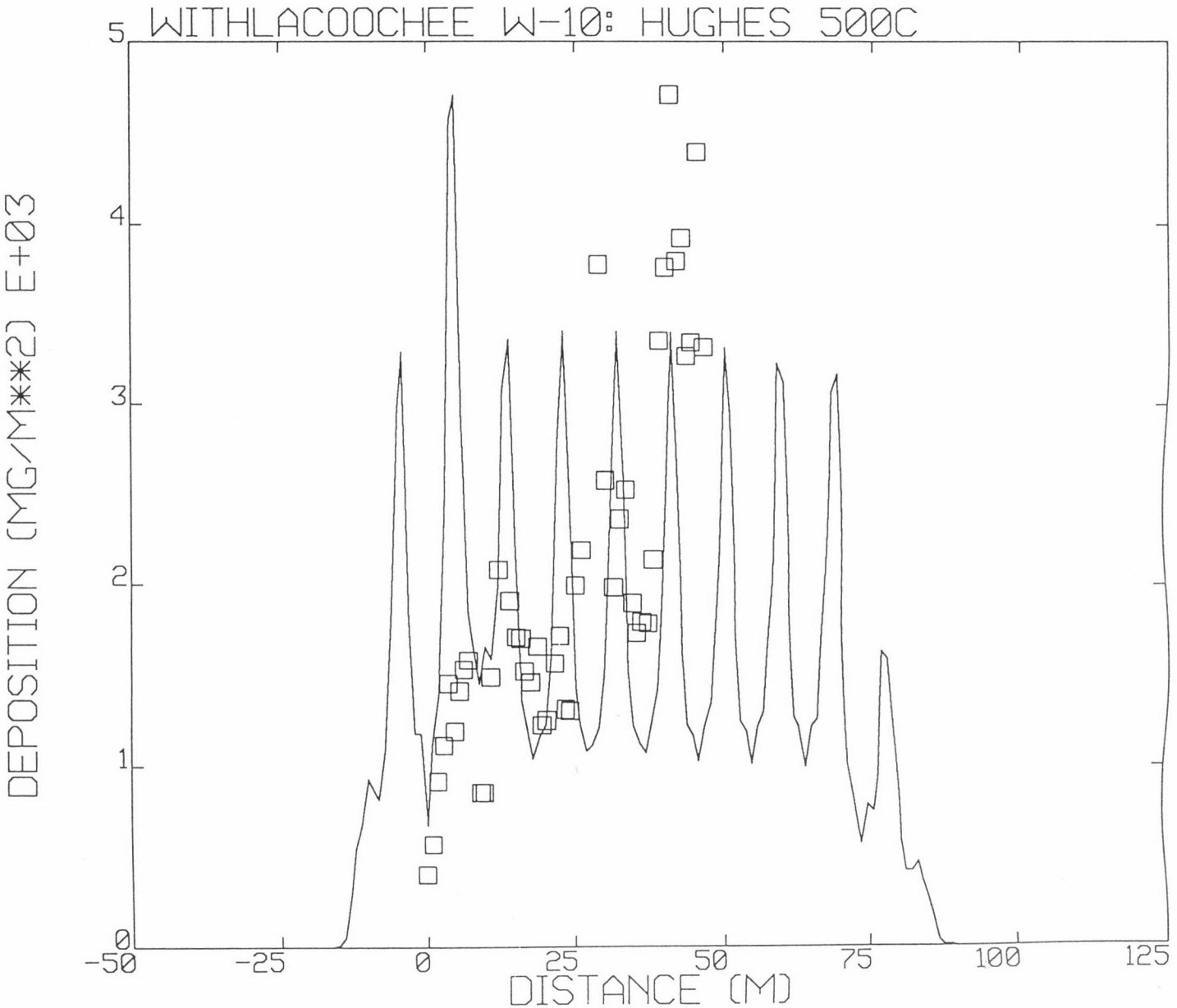

Figure 3-33. Predicted (solid curve) and averaged measured (open squares) ground deposition pattern for run W-10 at Withlacoochee (Hughes 500C).

Pesticide Precautionary Statement

Pesticides used improperly can be injurious to humans, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key--out of the reach of children and animals--and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary landfill dump, or crush and bury them in a level, isolated place.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or State extension specialist to be sure the intended use is still registered.

The use of trade, firm, or corporation names is for information and convenience of the reader. Such use does not constitute an official evaluation, conclusion, recommendation, endorsement, or approval of any product or service to the exclusion of others which may be suitable.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife - if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

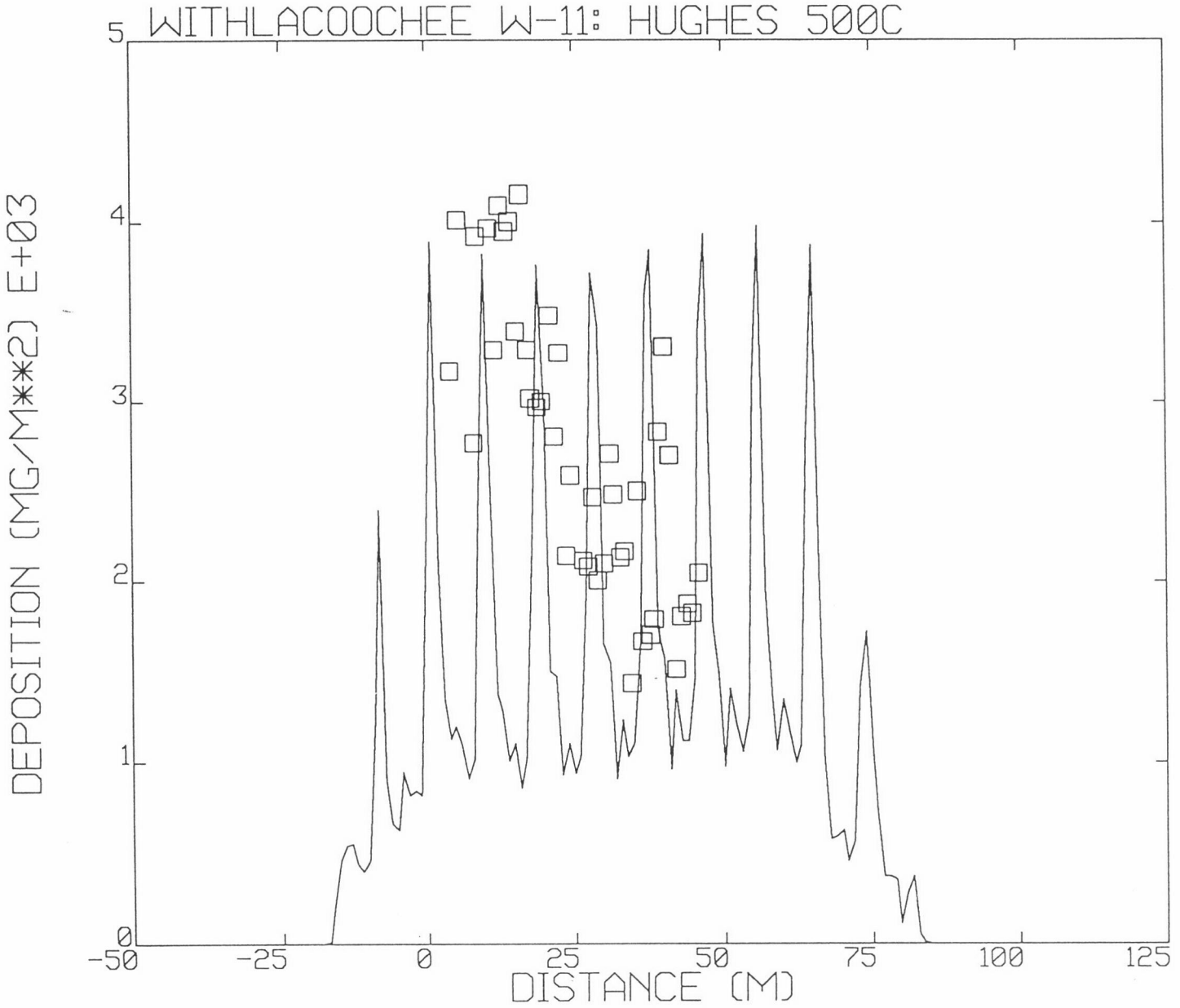

Figure 3-34. Predicted (solid curve) and averaged measured (open squares) ground deposition pattern for run W-11 at Withlacoochee (Hughes 500C).

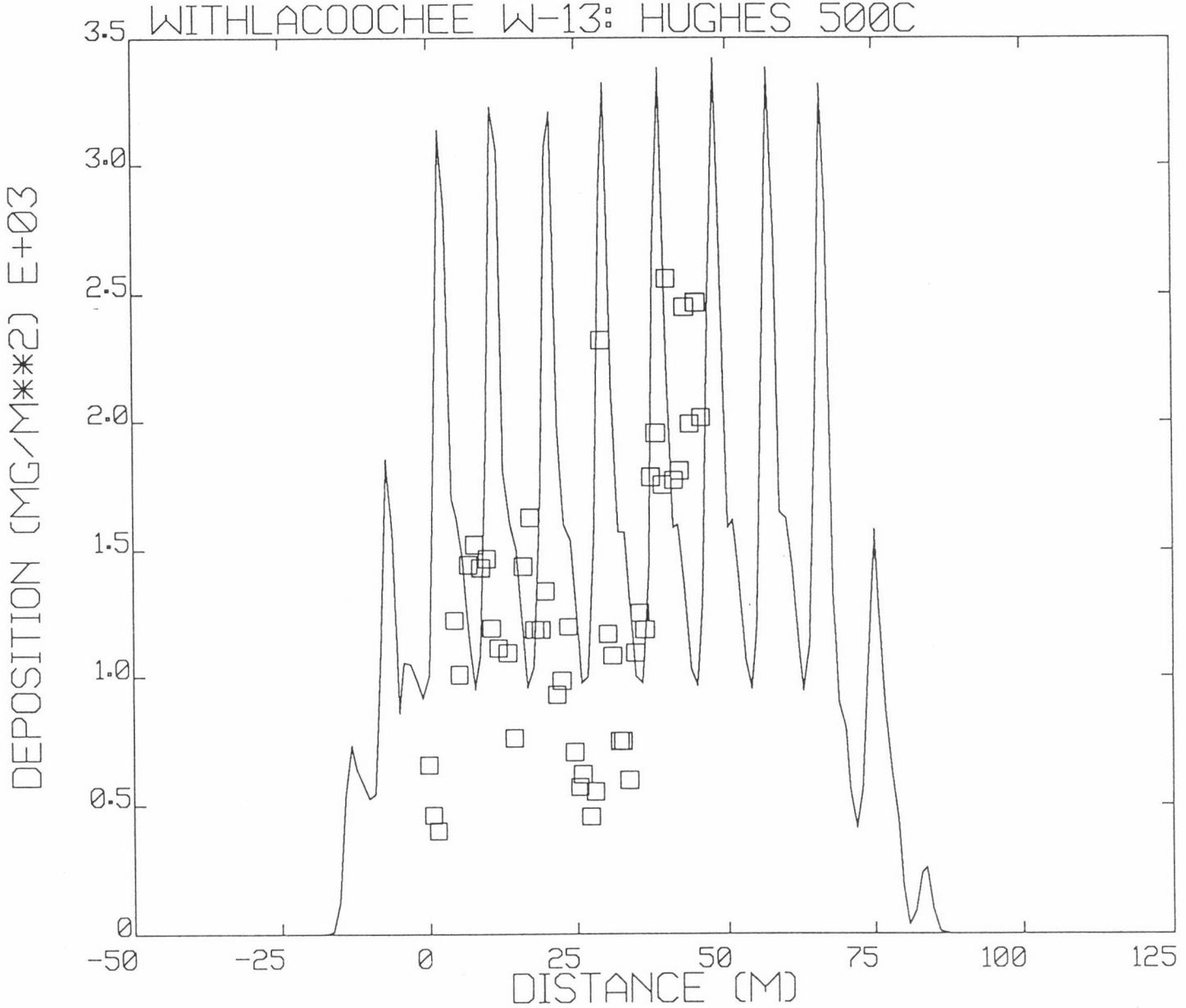

Figure 3-35. Predicted (solid curve) and averaged measured (open squares) ground deposition pattern for run W-13 at Withlacoochee (Hughes 500C).

4. CONCLUSIONS

The results presented in the previous section of this report compare AGDISP ground deposition predictions with field test data for both fixed and rotary wing aircraft. Several conclusions may be reached:

1. For the most part the field tests were not conducted with the anticipation of comparison with AGDISP predictions, necessitating the use of several assumptions and approximations to be able to initialize AGDISP. Future field tests should be aware of the detailed data needed to initialize AGDISP, and plan these tests accordingly. In this way ambiguity in AGDISP predictions may be reduced.

2. Over half of the field tests took place in a canopy. The comparisons shown here support the canopy deposition model in AGDISP.

3. The Red Bluff tests show clearly that the ground deposition data results are in error by the inability of the image analyzer to account for collection card moisture. It is suggested that future tests include the addition of several "control" cards placed near the actual ground collection cards. Just before flyover, a known quantity of deposition material is dropped onto the cards, and the cards are then removed from the aircraft flight path. The control cards should be handled and packaged along with the ground collection cards. In this way the image analyzer can be calibrated for moisture effect on the known deposition amount on the control cards before the ground collection cards are examined.

It is clear from the above analysis that an accurate set of data, including wind conditions, nozzle placement and aircraft flight conditions, are essential for code comparison to observed data. The wind speed and direction translate directly into crosswind and ambient turbulence level. The aircraft spray lines must be determined accurately as well, so as to be combined properly to recover the superimposed ground deposition pattern. Approximations and assumptions were made in the above data comparisons to fill in data gaps, yet the predictions are in reasonable agreement with the data.

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